An exploratory study of Techno-Quality Management in the future context

by

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Signed: *Mohd. Syaiful Rizal Abdul Hamid*

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Abstract

This research is focused on understanding how quality management and technology management fields have developed and evolved to date, how they are developing into the future, and to identify potential opportunities for convergences between these two fields. In the literature, these two fields are addressed independently. Likewise, literature in the areas of quality and technology management seem lack clarity in *how* quality management and technology management can be considered together, their inter-relationships and what the benefits of studying them together maybe. Therefore, this research gives a fresh look at the opportunity and potential of bringing the fields of quality management and technology management together. A single case study and in-depth literature review were employed as the research design approach. Five key data collection methods (mixed methods) were used: (1) Primary data from official company websites, (2) Primary data from 'hands-on trial observation', (3) Primary data from expert opinion survey via e-mail (electronic mail survey), (4) Primary data from face-to-face interview with scholar, and (5) Secondary data from documents (i.e. journal article and magazines). Also, four methods of analysis were used, namely: (1) Thematic analysis/content analysis (not CA), (2) Pattern matching, (3) Time series/historical analysis, and (4) Cause and effect analysis/Outcomes matrix. The in-depth literature review of the two fields identifies the need for understanding *how* each field emerged and evolved over time by mapping each using the framework of focus, principles, systems, tools and techniques. Accordingly, this historical review allows the researcher to establish the patterns of the framework on how it continues into the future. This review, coupled with the case study analysis led to the identification of four areas of synergy; continuous improvement, standards, leadership and partnerships/supplier relationships, which illustrates the overlapping points/convergences between quality and technology management fields in the future. In turn, this research further underlines and provides insights of *how would it change the way we manage quality management and technology management with respect to continuous improvement, standards, leadership and partnerships today,* which are presented as areas to be expanded for future research.

CHAPTER 1

Introduction

This research is about understanding how quality management and technology management fields have developed and evolved to date, as well as developing into the future and identify potential opportunities for convergences between these two fields. At the start of the research, the researcher was not focusing on the context. Context emerged from the research, as the network context emerged from the analysis of the literature only after having completed **Chapter 2** to **Chapter 5**. It needs to be clear that the findings of this study are limited to companies within that context (i.e. future context).

This chapter begins with the background to the research, research ideas and motivation of research, then leads to the identification of the research aims and the structure of the thesis.

1.1 Background to the research

The author's interest in these particular fields of study arose from previous personal experience in working with Onkyo Electric (Malaysia) Private Limited, dealing with the standards of quality systems such as International Organisation for Standardisation - ISO 9001: 2000, ISO 14000, Quality System - QS9000 and Technical System - TS 16949. As the researcher moved from industry to academia, the ideas arising from practice were built upon through the investigation of the areas of quality management and technology management in a broader context. Following from this the researcher carried out research relating to Malcolm Baldrige National Quality Award (MBNQA) model and Technology Management Process Assessment (TMPA) in high technology industry in Malaysia (Chew, Hamid, Yahya, & Mulyningrum, 2006; Hamid & Chew, 2006).

1.2 Research ideas, motivation of research and research aim

The quality management field has been studied for more than 100 years dating back to the early 1900s when Fredrick W. Taylor known as the father of Scientific Management, stressed the important of quality inspection (Foster, 2001, p. 44;

Garvin, 1988, p. 5). However, the study of technology management formally, is relatively young at only 20 years old. It is only since the 1980s that technology management has formally received widespread attention from both practitioners of management and academics (Drejer, 1997). In this study, based on researcher's personal industrial experience, the researcher believes that quality management and technology management are not mutually exclusive and there are some complementary aspects between these two fields. The experiences gained whilst dealing with the quality standards such as ISO 9001:2000, ISO 14000 and TS 16949 confirmed that quality has become a must in every process (Bagad, 2008; Dahlgaard, Kristensen, & Kanji, 2005; Lu & Kyokai, 1989) across various industries (e.g. manufacturing, food, construction and etc). But also, the researcher has witnessed the importance of technology (i.e. new product development in R&D), whereby technology has become the ultimate tools in providing added value (Betz, 1998; Khalil, 2000), whilst achieving competitive advantage for the firms over their competitors (Cory, 1996; Dussauge, Hart, & Ramanantsoa, 1994; Pilkington & Teichert, 2006; Tidd, 2000). Yet, in the literature these fields are addressed independently.

Having said that, there are few authors in the literature, who accentuate that quality and technology should be considered simultaneously (Ettlie, 1997; Nasierowski, 2000; Prajogo & Sohal, 2006; Zairi, 1993). For example, Nasierowski (2000) claims that, "*quality and technology should be viewed in a broad perspective that encompasses social acceptance and understanding, infrastructure and economic conditions surrounding business operations, as well as legal and competitive pressures, which force companies to excel and be innovative*" and expanding utilisation of quality standards and excellence models into the field of Technology Management (Dolinšek, Janeš, & Čosić, 2007). So, this reflects that there are some opportunities for merging these two fields in the future.

However, previous studies carried out by authors such as Ettlie (1997); Zairi (1993); Prajogo and Sohal (2006) in the areas of quality and technology management, seem lack clarity of how quality management and technology management can be considered together, their inter-relationships and what the benefits of studying them together maybe.

This research attempts to give a fresh look at the opportunity and potential of bringing the fields of quality management and technology management together. Therefore, the point of departure for this research is to better understand the potential for synergies, convergences, overlaps and conflicts in the two fields of quality management and technology management. The story line of initial stage of this research is shown in **Figure 1.1** as follows.

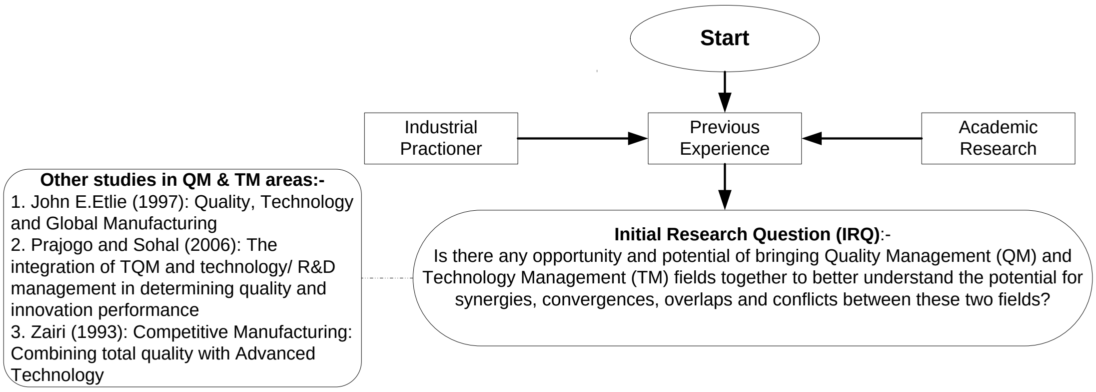

Figure 1.1: Story line of initial stage of research

1.3 Structure of the thesis

The thesis consists of eight chapters as illustrated in the following **Figure 1.4**. **Chapter 2** explores the research aim by conducting on an initial broad but shallow literature review of the two fields (i.e., quality management and technology management). As in this initial research, the researcher looked at common areas of quality management (QM) and technology management (TM), which are illustrated below in **Figure 1.2**: Quality Management and Technology Management merger.

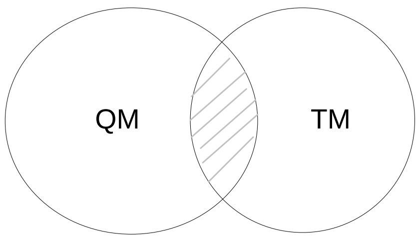

Figure 1.2: Quality and Technology Management merger

It identifies the need for understanding how each field emerged and evolved over time and concludes with a framework for mapping each field based on its focus, principles, systems, tools and techniques.

However, unlike quality management, the principles of technology management were not explicit. Therefore, **Chapter 3** identifies the principles of technology management as a result of consultation with technology management experts in order to elicit the key principles of technology management.

Chapter 4 presents in-depth literature review of the two fields with a view to understanding how each of these fields has developed or evolved over time. This literature review is presented with a particular emphasis on *how* each field developed in terms of focus, principles, systems, and tools and techniques. Accordingly, it appears that what drives the evolution of systems, tools and techniques of quality and technology management are the principles (i.e. principles as the driving force).

Chapter 5 outlines the projected business and global trends before predicting where these principles of quality and technology management will be in the future, as illustrated in **Figure 1.3**.

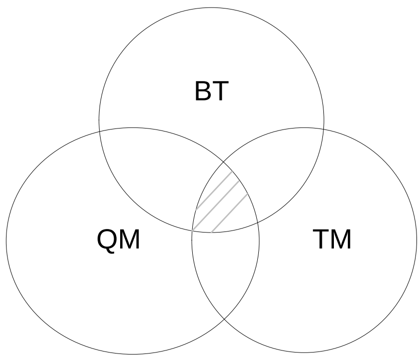

Figure 1.3: Quality management, Technology Management and Business Trend merger

The analysis of these projections enables the researcher to meet the aim of identifying potential areas of synergies, convergences, overlaps and conflicts in future developments of these two fields. Particularly, four areas of synergy strongly emerged from this analysis, namely; standards, continuous improvement, leadership, and partnerships/supplier relationships.

Furthermore, the analyses also revealed that networking is emerging as a future business model that may have a significant impact on the future of quality management and technology management. This prediction is consistent with a stream of literature that foresees the future of organisations lying in networking (Hamel, 2007; Malone, 2004; Salina & Salina, 2007).

This chapter concludes that the four potential areas, i.e., standards, continuous improvement, leadership, and partnerships/supplier relationships merit further study in the network context through case studies.

In **Chapter 6**, the thesis focuses on methodological framing of the research, including research paradigms and research strategies, as well as the research design and methods of research. In doing so, the researcher outlines that interpretivist as the research paradigm, and case studies and structured approach to literature selection as the most appropriate research design for this research.

Chapter 7 discusses the analyses and findings of the network cases based on Mozilla case. The main purposes of this chapter is to use the Mozilla case study to extend the conceptual framework, which was derived from literature, and evolve theory based on these analyses and mapping.

Chapter 8 presents the discussion and conclusions of the findings. It then details the contribution and implications of the work, demonstrates an assessment of the quality of the research and recommendations for further development in the area. It concludes with personal reflections of the researcher.

The thesis structure is summarised in **Figure 1.4** as follows.

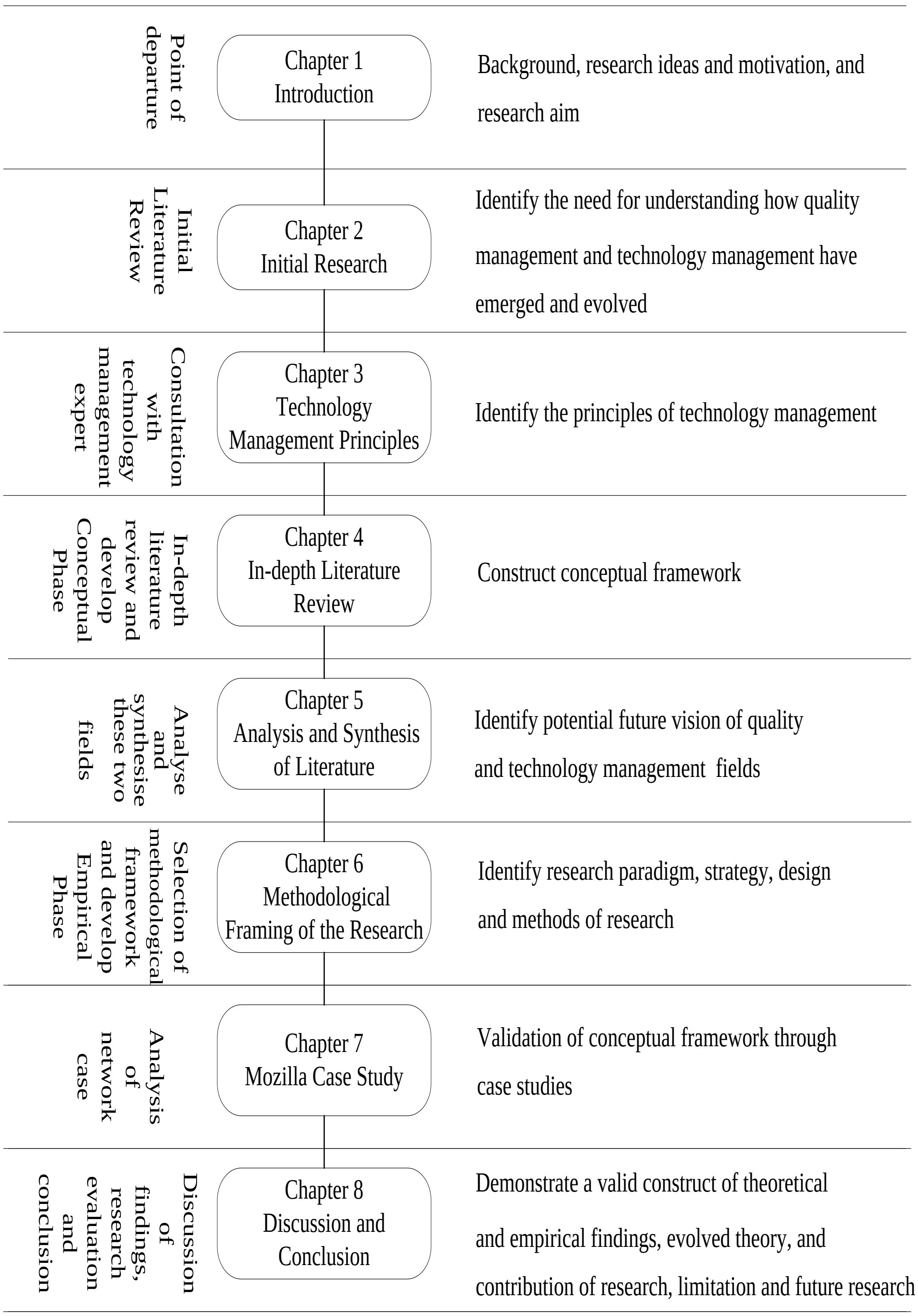

Figure 1.4: Structure of the thesis

CHAPTER 2

Initial Research

2.1 Introduction

This chapter presents an initial review of the two fields of quality management and technology management. In the comprehensive study of quality and technology management, it is vital to understand the fundamental points where quality and technology management come from, before predicting where these two fields will be in the future. The evolution of the quality and technology development and their interconnections over time are believed to be the factors that shape the ideas of the current progress of the quality management and technology management fields. Thus, this chapter identifies the need for understanding how each field emerged and evolved over time and concludes with a framework for mapping each field. Further, in order to make sense of the literature, and to find out the literature pertinent to quality and technology management, the researcher starts the literature search by identifying who the gurus/experts are in those fields, as illustrated below in **Figure 2.1** and then looking at their published works. The literature selection criteria used in literature review are further elaborated in following **Section 6.4.1** in **Chapter 6.**

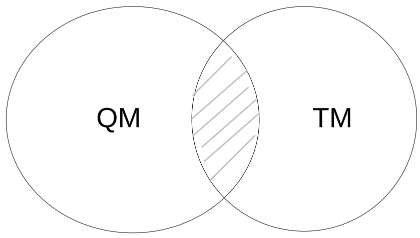

Figure 2.1: Quality and Technology Management merger

2.2 Quality Management Overview

Quality is a philosophy, an attitude and a way of thinking that is an integral part of successful industries, businesses, health care, education, and personal growth. It means doing the right things right, doing the right things effectively, and taking the right measurements to ensure excellence of the product or the service (Scarnati & Scarnati, 2002, p. 110).

"*Freedom from defects*" and "*fitness for use or purpose*" are the criteria used by Joseph Juran to define quality (Juran, 1988). He claims that once established, quality is free, whereas, the price of poor products or reworking products is high. Meanwhile Crosby suggests new essentials of quality management, which he calls "*The Absolutes"*.

- Quality is defined as conformance to requirements or goodness.
- Quality is achieved by prevention not appraisal.
- The quality performance standard in Zero Defect and is best known for no acceptable quality level.
- Quality is measured by the price of non-conformance not by indexes.

Source: American Society for Quality (2002, p. 34) based on Crosby (1984).

The term quality management can be defined as "*the systematic organisation to ensure efficient execution of appropriate tasks to meet the objective*" (Taylor & Pearson, 1994). Other definitions of quality and quality management are also reviewed to gain a further understanding of the quality management field. **Table 2.1** and **Table 2.2** indicate some of definitions of quality and quality management in the literature.

Table 2.1: Definitions of quality from several authors

Authors	Definitions
Feigenbaum (1961)	Quality does not mean "best" but "best for the customer use and selling price".
Taguchi and Wu (1979) cited from Hoyer and Hoyer (2001)	Quality is the loss a product causes to society after being shipped…other than any losses caused by its intrinsic function.
Crosby (1984)	Quality has to be defined as conformance to requirements.
Ishikawa (1985)	Quality does not only mean the quality of the product, but also of after sales service, quality of management, the company itself and human life
Deming (1986)	The customer's definition of quality is the only one that matters. Quality can be defined only in terms of the agent.
Juran (1988)	Quality is "fitness for use", recognises that a product or service must be produced with the customers' need in mind. "Freedom from defects" and "fitness for use or purpose".
Price (1990, p. 6)	Quality is giving the customer what he wants today, at a price he is pleased to pay, at a cost we can contain, again, and again, and again, and giving him something even better tomorrow. Quality is the degree of congruence between expectation and realisation. Quality is invisible when it is good, impossible to ignore when it is bad, an invisible input. Quality is not mathematical statistics. Quality is the application of simple statistical method. Quality is not status, grade or class.

Pirsig (1991)	Quality is not a thing. It is an event…Quality is the event at which awareness of both subjects and objects are made possible.
ANSI/ISO/ASQC A8402 (1994) cited from Stamatis (1996)	Quality is the "totality of characteristics of entity that bear on its ability to satisfy stated and implied needs".
Drucker (1989) cited from Richardson (1997)	Quality in a product or service is not what the supplier put in. It is what the customer gets out and is willing to pay for.
Foster (2001)	Ideal quality refers to a reference point or target value for determining the quality level of a product or service.
American Society for Quality (2002) based on Deming (1993)	Quality means a predictable degree of uniformity, dependability at low cost and suited to the market.
American Society for Quality (2002)	Quality relates the features and characteristics of a product or service to the ability of that product or service to satisfy stated or implied needs (ANSI/ASQC) A3-1987. Quality is the degree to which a set of inherent characteristics fulfils requirements (ANSI/ISO/ASQ) Q9000-2000.
Dahlgaard, Kristensen and Kanji (2002)	Quality is to continuously satisfy customers expectations.
Slack, Chambers, Johnston and Betts (2006, p. 40)	Doing things right, providing error-free goods and services that are 'fit for their purpose'.

Table 2.2: Definitions of quality management from several authors

Authors	Definitions
DISC TickIT Office (1992, p. 35)	Quality management is that aspect of the organisational function that determines and implements the quality policy. On a particular project, this is achieved through the functions of quality assurance and quality control.
Godfrey, Dale, Marchington and Wilkinson (1997, p. 560) based on BS/EN/ISO 8402 (1995)	All aspects of the overall management function that determine the quality policy objectives and responsibilities, and implement them by means such as quality planning, quality control, quality assurance and quality improvement within the quality system.
Sousa and Voss (2002) based on Dean and Bowen (1994)	Quality management has been defined as "philosophy or an approach to management" made up of a "set of mutually reinforcing principles, each of which is supported by a set of practices and techniques".
American Society for Quality (2002)	The application of quality management system in managing a process so as to achieve maximum customer satisfaction at the lowest overall cost to the organisation while continuing to improve the process.

Oakland (2000) claims that the increased awareness of senior executives, who have recognised that quality is an important strategic issue, is reflected as an important focus for all levels of the organisation. This requires defining and implementing several quality factors. These quality success factors include top management commitment and involvement. Such factors are known as the soft aspects of management, while the hard aspects include factors such as improvement tools and techniques and systems (Oakland, 2000; Wilkinson, 1992).

In this research, the researcher defines quality as **the situation where the stakeholders are truly confident in the system and that it meets their expectations by knowing what to do, doing it correctly and continuously improving, as it evolves through the learning process**. Consistent with Dean and Bowen (1994); Sousa and Voss (2002), the researcher has synthesised their definition and proposes that **quality management is a managerial philosophy or an approach made up of a set of mutually reinforcing principles, each of which is supported by a set of practices, tools and techniques for enduring effectiveness and efficiency with respect to the systems and its performance**.

In general, it appears that there is agreement in the definitions of quality and quality management means although different authors use different terminology. Therefore, the researcher would say that there seems to be no conflict or argument between the authors.

However, it is fair to say that correctness is typically one of the most important aspects of quality, yet this has been a struggle in quality context. So, **Table 2.3** below illustrates some definitions of quality correctness terms for a better understanding the concept of correctness in quality context and the explanation comes after the table.

Table 2.3: Description of quality correctness from several authors

Terms	Description	Authors
Error	A human action that produces an incorrect result.	Tian (2005); Kremer & Fabrizio; (2005); Patty & Denton (2010)
Defect	The result of any deviation from product specifications that may lead to customer dissatisfaction.	Kremer & Fabrizio; (2005); Tian (2005); Patty & Denton (2010); Stamatis (2003)
Defective	A unit of product that contains one or more defects with respect to the quality characteristics under consideration.	ASQ at http://asq.org/glossary/d.html

Mistake	The knowledge-based error whereby an action proceeds as planned but fails to achieve the intended outcome because the planned action was incorrect	Kopec, et al., (2006); Stamatis (2003)
Failure	The inability of a system or component to perform its requirement functions within specified performance requirements due to one or more defects	ASQ at http://asq.org/glossary/d.html; Tian (2005)

According to Tian (2005) the term failure refers to "*a behavioural deviation from the user requirement or the product specification*". While, errors refers to "*a missing or incorrect human action resulting in certain incorrect result"* (Tian, 2005). Consistent with this, (Patty & Denton, 2010) claim that an error "*is a deviation from manufacturing, engineering or business standards with the potential for causing defects in products or services"*. Likewise, Stamatis (2003) claims that "*a defect is the result of any deviation from product specifications that may lead to customer dissatisfaction.*" Further, the term defective refers to a unit of product that contains one or more defects with respect to the quality characteristics under consideration. See American Society for Quality (ASQ) at http://asq.org/glossary/d.html.

Other than that, a mistake is a knowledge-based error whereby an action proceeds as planned but fails to achieve the intended outcome because the planned action was incorrect (Kopec, et al., 2006). Hence, mistakes typically occur from a lack of or misapplication of knowledge (Kopec, et al., 2006). Additionally, mistakes are inevitable, and errors can be eliminated (Stamatis, 2003).

In short, the researcher would describe that error and mistake are associated with people. Failure is closely associated to the inability of a system or components to perform upon the required functions on demands due to one or more defects. While, defect is closely associated to a product or service non-fulfilment of an intended requirement or reasonable expectation for use and apparently, this leads to defective - the result of any deviation from product specifications that may lead to customer dissatisfaction.

Further, it is also believed that the patterns of quality management literature are influenced by the big gurus' thinking (i.e. Shewhart; Deming; Juran; Crosby, Feigenbaum and Ishikawa) which reflects the stream and direction of quality movement as they are today. In order to further understand the quality management movement and to predict its future, the researcher also looks at the origins and the evolution of this field. Thus, in doing so, the historical review allows the researcher to establish the patterns of quality management focus, principles, systems, and tools and techniques, which is presented in **Chapter 4** (Analysis and synthesis of the literature).

2.3 Origins and Evolution of Quality Management

Authors such as Garvin (1988) link the era of quality management with time series; i.e., from Inspection Era to Statistical Quality Control Era, Quality Assurance Era and the latest Strategic Quality Management Era. Powell (1995) also discusses TQM relative to time. In this chapter, the researcher proposes that the development and origins of quality management can also be traced to the **focus** of quality over the time.

Traditionally quality is used for inspection as a method of measurement to detect the errors in production manufacturing. According to Foster (2001) and Garvin (1988) the driving force of inspection activities was inspired by Frederick Taylor (the father of Scientific Management) in the early 1900s. Through the years, the interest in quality has evolved when G.S Radford published his book named The Control of Quality in Manufacturing in 1922 (Garvin, 1988, p. 5). It defined quality as a distinct management responsibility and as an independent function yet, at that time, the primary focus was inspection (Dahlgaard, et al., 2002; Garvin, 1988, p.5). Meanwhile Henry Ford developed the Model T which later became the Ford car and introduced the moving assembly line, which lead to the concept of mass production (Roth, 1996; Womack, Jones, & Roos, 1990). The Model T was described as the first product of mass production, which was developed to produce the Model T in great quantities (Batchelor, 1994, p. 66; Roth, 1996). Moreover, Womack, et al., (1990, p. 27) note that "*the key to mass production wasn't – as many people than and now believe – the moving, continuous, assembly line. Rather it was the complete and consistent **interchangeability** of parts and the simplicity of attaching them to each other. These were the manufacturing innovations that made the assembly line* *possible".* This interchangeability reflects the quality in the form of standardisation, which reduce the variation in the parts.

Between 1930s and 1940s, statistics became the main method of influence for the quality management discipline. In 1938, Deming published a technical book and taught courses in the use of his statistical methods (ASQ, 2002, p. 20). Deming thinking was centred to problem solving in process management, when he proposed the Deming Cycle (Plan-Do-Check-Act). This was influenced by Shewhart who at that time was concerned with the use of Statistical Quality Control (SQC) in reducing the variation in production (ASQ, 2002).

As such Garvin (1988, p. 6) notes that in 1931, Shewhart had published Economic Control of Quality of Manufactured Product**,** in which he gave a precise and measurable definition of manufacturing control, developed powerful techniques for monitoring and evaluating day-to-day production, and suggested a variety of ways of improving quality. Garvin states that Shewhart's book is considered by many to be the origin of the basic principles of quality. Moreover, the book was considered by statisticians to be a landmark contribution to the effort to improve the quality of manufactured goods and he made the utmost valuable contribution to quality development with the concepts of Statistical Control or processes known today as SPC (ASQ, 2002, p. 29). Garvin adds that the development of quality management during that time was heavily influenced by statistical methods and their application. This was further developed during 1940s in the work of Bell Laboratories, which initiated and developed sampling techniques, namely Acceptable Quality Levels (AQL) and Average Outgoing Quality Limit (AOQL) (Garvin, 1988). Therefore, it is a general belief that during the period from the early 1900s to 1940s, the philosophy of quality was focused on the **product** (i.e. product focus). The process of inspection and control was aimed at detection and rejection at the point of production (i.e. *How can we ensure quality in a product*?).

The 1950s could be considered as the turning point of the quality management field. During that decade, the Japanese Industrial Revolution had rapidly begun. Earlier in

1946 the Union of Japanese Scientist and Engineers was founded, which went on to introduce the Deming Prize in 1951. At this time, the Japanese Industrial Standards Committee was established, and they have played a major role in the development of the quality movement in Japan. As such, several tools and techniques were implemented and are still being practiced in across the world. These include Statistical Process Control (originated from Statistical Quality Control), Reliability Engineering, Kaizen and Genba-Kaizen, Failure Mode and Effect Analysis, Poka-Yoke (mistake proofing), Jidoka and Just-in-Time and Total Preventive Maintenance (Foster, 2001; Richardson, 1997).

Meanwhile, Juran published his first edition of the Quality Control Handbook in 1951. Its initial chapter discusses the economics of quality and proposes the famous analogy *gold in the mine*. He divided quality into avoidable and unavoidable causes (Costs of Quality). As such, in Statistical Quality Control, he estimates that 15% of quality problems in a company are due to special causes, which means that they may involve the workers. In his view, 85% or more are down to management dealing with the system (quality in operation system). Therefore, he believes that problems can be solved by moulding the processes of the system.

In 1961, Feigenbaum published his book on Total Quality Control (TQC). He argued for a systematic or total approach to quality, requiring the involvement of all functions, not just manufacturing, in the quality process. He argued that the underlying principles of this total quality is to provide genuine effectiveness control which must start with design of the product and end only when the product has been placed in the hands of the satisfied customer. In short, quality starts to become a must in every process. It is clear that the idea was to build in quality at an early stage rather than inspecting and controlling quality at the end of the production process.

In Japan, Ishikawa developed the Ishikawa Diagram as a management problem solving tool in 1943 (Dahlgaard, et al., 2002, p. 90; Ishikawa, 1985, p. 64). In early 1960s, Ishikawa produced a non-technical quality analysis textbook for quality circle members. Ishikawa's quality circles where first piloted at the Nippon Telegraph and

Cable Company in 1962. He published a book entitled "What Is Total Quality Control" in which seven basic tools (7 Quality Tools) were described as indispensable for quality control (Ishikawa, 1985, p. 198).

In turn, another Japanese scholar in quality engineering progress is Taguchi. In 1951, he won the Deming Award for Literature on Quality and in 1960 he won the Deming Application Prize. Along the way, Taguchi developed the concept of the "quality loss function" and his methods are concerned with the routine optimisation of product and process prior to manufacture, rather than reliance on the achievement of quality through inspection. Concepts of quality and reliability are pushed back to the design stage. The Design of Experiments (DOE) method provides an efficient technique to design product tests prior to entering the manufacturing phase (Foster, 2001; Richardson, 1997, p. 9). This method is aligned with the concept proposed by Feigenbaum where quality is built in to every process of production. It seems that at this stage the focus of QM has moved from product to process (i.e. *How can we ensure quality in process?*).

In 1979, standards, quality accreditation and quality systems were first introduced, with British Standard (BS) 5750 since revised in 1987 (Bank, 2000; Callan, 1992; Hill, MacGregor, & Dewar, 1996), and which later became the BS EN ISO 9001:2000. Meanwhile, Womack et al., (1990, p. 159) claim that Ford started a systematic supplier grading system, called Q1, in the mid-1980s. This is a complex statistical system, which ranks suppliers by the number of defects discovered in the assembly plant, delivery performances, progress in implementing quality, improvement programs in the supplier plant, level of technology and management attitudes. The aim was to bring every supplier gradually up to higher and higher levels of performance and quality.

Following on from this, 1987 was a pivotal year for quality management when the International Standards for Organisation (ISO) and The Malcolm Baldrige National Quality Award were established. ISO developed the ISO 9000 series that set out methods by which a system can be implemented, to ensure that the specific quality requirements are fulfilled (ISO 9000:1987). See also ISO standards at www.iso.org/iso_catalogue.htm.

On the other hand, the criteria for Malcolm Baldrige Model were established by the approach that reflected a consensus of best practice, and an annual review process was put in place to ensure that the Baldrige Model continues to reflect evolving trends (Hakes, 1999).

The development of a standard European approach followed quickly on from the Baldrige experience. In September 1988, the leaders of 14 major European countries played a key role in establishing the European Foundation for Quality Management (EFQM). EFQM established its own model in 1991, named Business Excellence Model for the European Quality Award, which built upon the Deming and Malcolm Baldrige approaches (Hakes, 1999). Looking at the system as a whole, it covers all processes that are embedded within it. All of these models recognise the interdependencies between various components in the system (i.e. leadership shapes strategy, people, standardise processes, and cause and effect relationships) as all of these are interrelated. For example, Malcolm Baldridge Model consists of processes for meeting the company quality goals as these processes are measured by information management, strategic quality planning, human resource management, product and process management, and part of the customer focus and satisfaction category. While EFQM system recognise how leadership drives policy and strategy that is delivered through people, partnerships and resources, and processes. Therefore, it is suggested that all of these integrated managerial systems reflect the system focus. As it is clearly seen, the quality journey during this period from **1960s to 1980s** was focused on the **system** (i.e. *How can we ensure quality in the system?*)

Crosby's first book "Quality Is Free" in 1979 sold over 2 million copies and has been translated into 15 languages. Much of "Quality Is Free" is devoted to the concept of zero defects, which is a way of explaining to employees the idea that everything should be done "right first time", that there should be no failures or defects in work outputs. His thinking places greater attention on the people aspects of quality management (Crosby, 1979). Meanwhile, in 1984, Crosby published his second bestseller “Quality without Tears”. The 14 points that Crosby considered essential involve the following ideas: management commitment, education and training, measurements, cost of quality, quality awareness, corrective action, zero defects, goal setting and recognition (Crosby, 1984). Therefore, it is fair to say that Crosby initiates a new perspective on quality which considers it through organisational lenses.

During the 1990s, Total Quality Management (TQM) became central in the agenda of top management. According to Dahlgaard and Dahlgaard (2003) Total Quality Management (TQM) is a relatively new management philosophy, which has evolved from the rather narrow and mechanistic approach of Statistical Quality Control (SQC) as discussed earlier, to a more holistic and humanistic approach. The concept of TQM is a logical development of the concept of Total Quality Control (TQC), as introduced by Feigenbaum in 1961. In addition, another humanistic-oriented quality standard named the Investors in People (IIP) was launched in October 1991, based on widely-accepted principles of best training and development practices to enable organisations to improve their training and enhance their performance (Mason, 1997, p. 1).

Slowly but gradually, by this time, there seems to be more attention given to people with the system (people spin), in the development of quality journey. As these can be seen with the increased focus on Investors in People (1991) for the Best Training and Development Practices, European Foundation for Quality Management (1992) for Business Excellence Model (BEM); e.g. leadership with excellent mindset and OHSAS 18000 (1996) for Occupational Health and Safety Management System.

Following on from this, the emphasis on **system focus** still continues with Six Sigma and Lean Manufacturing made the headlines during the 1990s. Mikel Harry (Motorola) first published “The Nature of Six Sigma” in 1986 and commercialised Six Sigma as a vibrant quality-improvement methodology (Eckes, 2005). The philosophy was given global boost in 1998 by Jack Welch then CEO of General

Electric (Eckes, 2005; Miles, 1999). Another philosophy emerging at this time was Lean Manufacturing which derives from the Toyota Production System (TPS) or Just in Time (JIT) manufacturing. The lean manufacturing concept was popularised in American factories in large part by the Massachusetts Institute of Technology, who studied the movement from mass production toward Lean production as described in "The Machine That Changed the World: The Story of Lean Production" (Womack, et al., 1990).

Systems have further developed with the implementation of TickIT, originally set up by UK Department of Trade and Industry and administered by British Standards Institution (BSI). This standard applies to suppliers of all types of information systems that involve software development processes. TickIT is based on ISO 9001:2000 but tailored for software related activities Department of Trade and Industry (1992). Further, the International Automotive Task Force (IATF) has developed ISO/TS 16949 for automotive related products. The system enables continuous improvement, emphasising defect prevention and reduction of variation and waste in the supply chain. ISO/TS 16949 mainly applies to design/development, production, installation and servicing of automotive related products, and is the replacement of QS 9000: 1998 - International Automotive Task Force (IATF, 2002). In turn, the ISO 9000 series progress with the revised version in 2008. Therefore, this was the time when overlapping occurred within the quality movement journey with the focus on both **system** and **people**.

Today's there seems to be an increased awareness of Corporate Social and Environmental Responsibility that obliges the business sector to play a sensible yet not solely profit-oriented role. This includes social and environmentally driven actions, where the business sector has been expected to go beyond its moneymaking and commercial activities to commit to the well-being of the community. This has led to the introduction of ISO 26000 (standards for Social Responsibility), which will be published in 2010 will act as a guideline for dealing with corporate social responsibility and the environment.

Castka and Balzarova (2008) insist that the new ISO 26000 should be closely aligned with ISO 14000 and requires organisations to develop their management systems around their social responsibility (i.e. people orientation) aspects and impacts. Over time, it is becoming clear that the quality focus has moved from a **system focus** to a **people focus.** It is clear that the current development of quality management is focused on people with an extended view towards corporate social responsibility and environment. In other words, from the beginning of the 1980s to the present the main idea is centred on understanding *how can we ensure quality in people*? **Table 2.4** below summarises the quality management literature over time.

Table 2.4: Important events in the development of quality management

Key Focus	App. Time	Key Events	Key References
How can we ensure quality in product?	1900	**Fredrick W. Taylor** calls as the father of Scientific Management stressed on inspection activities	Garvin (1988); Foster (2001)
	1910s	**Henry Ford** came out with Model T (became the Ford car) and introduced of moving assembly line which lead to mass production concept (quality interchangeability)	Batchelor (1994); Womack, et al., (1990)
	1920s	**Walter Shewhart** of Bell Laboratories developed a system for measuring variance in production system, known as statistical process control. Shewhart also created the Plan-Do-Check-Act (PDCA) cycle, which applies a systematic approach to improving work processes	Garvin (1988)
	1922	Inspection activities were linked more formally to quality control with the publication of **G.S Radford's** The Control of Quality in Manufacturing. Quality was viewed as a distinct management responsibility and as an independent function	Garvin (1988)
	1924	**Walter Shewhart** of Bell Laboratories developed **Statistical Process Control** (SPC)	American Society for Quality (2002)
	1926	**The Bell Telephone** began to apply statistical control methods	Martinez-Lorente, Dewhurst and Dale (1998)
	1931	Shewhart has published **Economic Control of Quality of Manufactured Product**, giving the discipline a scientific footing for the first time. Shewhart gave a precise and measurable definition of manufacturing control, developed powerful techniques for monitoring and evaluating day-to-day production, and suggested a variety of ways of improving quality	Garvin (1988); American Society for Quality (2002)
	1938	Deming published a technical book and taught courses in the use of his statistical methods	American Society for Quality (2002)
	1939	Shewhart wrote Statistical Method from the viewpoint of Quality Control Shewhart's idea for the Plan-Do-Check-Act cycle was used extensively by Deming and others to help management quality improvement projects	American Society for Quality (2002) Garvin (1988); American Society for Quality (2002)
	1940	A committee was formed in December by the American war department to draft standards in the area quality	Garvin (1988)
	1942	A quality control section was established in the war department staff mainly by statisticians from Bell Laboratories. This group developed a new set of sampling, tables based on the concept of acceptable quality levels (AQL)	Garvin (1988)

	1943	Ishikawa invented Fish-Bone diagram which bears his name as **Ishikawa Diagram** as management problem solving tools	Dahlgaard, et al., (2002)
	Mid-1940s	The American army pushed the use of sampling methods during World War II	Martinez-Lorente, Dewhurst and Dale (1998)
	1946	Japanese Industrial Standards Committee is established. Union of Japanese Scientists and Engineers **(JUSE)** is established Deming involved with the Union of Scientists Engineer (JUSE) after its formation	Garvin (1988) American Society for Quality (2002); Foster (2001)
How can we ensure quality in process?	1950	First visit of Deming to Japan. Deming give a talk and taught Japanese's leaders about statistical quality control techniques (SQC) **JUSE** publishes the magazine Statistical Quality Control. Japanese Industrial Standards are established under the Industrial Standardization Law	Garvin (1988); Foster (2001); Bank (2000); Martinez-Lorente, Dewhurst and Dale (1998)
	1950s	**Failure Mode Effect Analysis (FMEA)** developed by US military after the Korean war. **Reliability engineering** developed by American Department of Defence which formed an Ad Hoc Group on Reliability of Electronic Equipment The basis of the **kaizen** revolution in Japan that took place in the 1950s along with the used of **Kanban, Jidoka** and **Just in Time (JIT)** together to continually improves production processes Taiichi Ohno, who is generally recognised as the 'father of JIT' due to his pioneering work at Toyota in the 1950s and 1960s. Preventive maintenance was introduced in the 1950s where in Japan Total Productive Maintenance (TPM) is called Preventive Maintenance	Bounds, Yorks, Adams and Ramney (1994); Gower (1990) Richardson (1997); Gower (1990); Louis (1997); Dahlgaard, et al., (2002) Nakajima (1988); Richardson (1997)
	1951	**Deming Prize** is established in Japan Juran published his first edition of **Quality Control Handbook**	Garvin (1988); Foster (2001); Dahlgaard, et al., (2002) Garvin (1988); Bank (2000); American Society for Quality (2002)
	1954	First visit of Juran to Japan	Garvin (1988); American Society for Quality (2002)
	1956	Armand Feigenbaum introduced total a principe called **Total Quality Control** (TQC) which underlying principles to provide genuine effectiveness control must start with design of the product and end only when the product has been placed in the hand of the customer who remain satisfied	Garvin (1988); Feigenbaum (1961)
	Early 1960s	Ishikawa is best known as a pioneer of the "**quality circle**" movement in Japan	American Society for Quality (2002)
	1960s	Crosby invented the concept of **Zero Defects** Goals in 1960s. Crosby lists for new essentials of quality management which he calls "**The Absolutes**"	Crosby (1979); Garvin (1988); American Society for Quality (2002); Bank (2000)
	1961	First edition of **Feigenbaum's Total Quality Control**	Martinez-Lorente, Dewhurst and Dale (1998)
	1962	Ishikawa's quality circles where first piloted at Nippon Telegraph and cable company. Published a book named **What Is Total Quality Control**	Bank (2000); American Society for Quality (2002)

How can we ensure quality in system?		The idea of quality circles appeared in the first issue of the Japanese journal Quality Control for the Foreman (Genba-To-QC)	Garvin (1988)
	1968	Ishikawa produced a non-technical quality analysis textbook for quality circle members Most large Japanese companies had adopted what Ishikawa called **Companywide Quality Control** (CWQC) in Japan to produce world-class quality products	American Society for Quality (2002) Garvin (1988); American Society for Quality (2002)
	Early 1970s	Taguchi developed the concept of the **Quality Loss Function**. The method provides an efficient technique to design product tests prior to entering the manufacturing phase	American Society for Quality (2002)
	1970s	The established of **Toyota Production System (TPS)** with the key elements are Just-In-Time (JIT), Jidoka, Standardised Work and Kaizen	Womack, et al., (1990)
	1972	**Quality Function Deployment** was first practiced at Kobe Shipyard, Mitsubishi Heavy Industries, Ltd.	Garvin (1988); Bank (2000); Zairi (1994)
	1973	After the 1973 oil crisis, the JIT system was adopted by a vast number of Japanese companies. A small number of American and European companies began to apply this system in the 1980s	Martinez-Lorente, Dewhurst and Dale (1998)
	Mid-1970s	Quality circles began to be widely introduced in the USA, the first quality circle programme was launched in Lockheed in 1974 and in the UK it was Rolls-Royce which introduced the concept in 1979	Martinez-Lorente, Dewhurst and Dale (1998)
	1979	First edition of Crosby's Quality Is Free Xerox Corp. started to apply the benchmarking concept to processes Publication of the BS 5750 quality management series	Crosby (1979); American Society for Quality (2002) Bank (2000) Bank (2000); Hill, et al., (1996); Callan (1992)
How can we ensure quality in people?	1980	The Taguchi method design of experiments **(DOE)** was first introduced by Dr. Genichi Taguchi to AT&T Bell Laboratories	Foster (2001)
	1980s	The establishment of **Total Quality Management (TQM**) which is a management approach that originated in the 1950s	Foster (2001)
	1982	First edition of Deming's Quality, Productivity and Competitive Position	Martinez-Lorente, Dewhurst and Dale (1998)
	1984	Crosby published his second bestseller "Quality Without Tears"	Crosby (1984); Foster (2001)
	Mid-1980s	**Ford** started a systematic supplier grading system, called **Q1**	Womack, et al., (1990)
	1986	First edition of Deming's Out of the Crisis. It became a bestseller	American Society for Quality (2002)
	1987	First edition of **ISO 9000** quality management system series Publication of the **Malcolm Baldrige National Quality Award** **BS 5750** revised in 1987	American Society for Quality (2002); Bank (2000) Bank (2000); Dahlgaard, et al., (2002)
	1990s	**Xerox** introduced leadership through quality as a vehicle for change. **Six Sigma** was developed at Motorola. Lean Manufacturing derives from the Toyota Production System or Just in Time Production. The "lean manufacturing" concept was popularized in	Garvin (1988) Eckes (2005, p. 12) Womack, et al., (1990)

		American factories in large part by the Massachusetts Institute of Technology study of the movement from mass production toward production as described in **The Machine That Changed the World: The Story Of Lean Production.**	
	1991	National Training Task Force introduced **Investors in People (IIP)** in October 1991	Mason (1997)
	1992	The **EFQM Excellence Model** was introduced at the beginning of 1992 as the framework for assessing organisations for the European Quality Award	Dahlgaard, et al., (2002)
	1994	**QS 9000** is developed by Daimler-Chrysler, Ford & General Motor where it is based on ISO 9001: 1994. The system became effective on September 1, 1994	Stamatis (1996)
	1996	First edition of **ISO 14000** environmental management series First edition of **OHSAS 18000** - occupational health and safety management series, which derived from the British Standard BS8800:1996	International Organisation for Standardisation at www.iso.org; Moris (2004) International Occupational Health and Safety Management at www.ohsas-18001-occupational-health-and-safety.com; British Standards Institute at www.bsigroup.com
	1998	**QS 9000** reissued in March 1998	Stamatis (1996)
	Early 2000	**TickIT** originally set up by UK Department of Trade and Industry and administered by British Standards Institution (BSI), which applies to all types of information system supply, which involve software development processes	TickIT (1992)
	2000	**The 2000 edition** of the **ISO 9000** was established	American Society for Quality (2002)
	2002	**International Automotive Task Force (IATF)** - automakers General Motor, Chrysler and Ford developed ISO/TS 16949:2002	International Automotive Task Force (IATF) (2002)
	2008	**The 2008 edition** of the **ISO 9000** was established	International Organisation for Standardisation at www.iso.org; (Arter & Russell, 2009)
	2010 – Future?	**ISO 26000** standard for Social Responsibility	Castka and Balzarova (2008)

Following on from this, in the next section, the researcher illustrates the overview of technology management, reviews some of the definitions of technology and technology management, before discussing the evolution of technology management with a view to gain a better understanding of this field.

2.4 Technology Management Overview

Betz (1993) states that technology is a key resource of profound importance for corporate profitability and growth. It also has enormous significance for the well-being of national economics as well as international competitiveness. Effective technology management links engineering, science and management disciplines to address the issues involved in the planning, development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organisation (Betz, 1993).

Gaynor (1996) accentuates that technology includes more than machines, processes, and inventions. He further claims that a description of technology in technology management context must go beyond the traditional, where technology can be described in the different ways as follow:

(i) Technology is the means for accomplishing a task - it includes whatever is needed to convert resources into products or services.

(ii) Technology includes the knowledge and resources that are required to achieve an objective.

(iii) Technology is the body of scientific an engineering knowledge which can be applied in the design of products and/or processes or in the search for new knowledge.

2.4.1 Defining Technology

Table 2.5 as follows**,** shows some of definitions of technology from several authors in literature.

Table 2.5: Definitions of technology from several authors

Authors	Definitions
Galbraith (1974)	Technology means the systematic application of scientific or other organised knowledge to practical tasks.
Kilmann (1979)	Technology as a step-by-step sequencing of decisions and actions which, as a total "package", brings about some planned and purposeful change in an organisation or social system…these decisions and actions guided by substantive knowledge (theory) of how these decisions and actions can best be made, based on what is currently known.
Rousseau (1979)	Technology as a process of transforming input into output is virtually by definition open and responsive to environmental influences.
Gerwin (1979)	Technology as the actions individual performs on objects to change them, and structure was taken to mean individuals interacting with other in the course of trying to change objects.

Mills and Moberg (1982)	Technology is applicable at all stages of the system, not just within the so-called conversion process.
Zeleny (1986)	Technology consists of three interdependent, codetermining and equally important components. 1. Hardware: The physical structure and logical layout of the equipment or machinery that is to be used to carry out the required tasks. 2. Software: The knowledge of how to use the hardware in order to carry out the required tasks. 3. Brainware: The reasons for using the technology in particular way. This may also be referred to as the “know-why”.
Betz (1993)	Technology is a key resource of profound importance for corporate profitability and growth.
Rogers (1995)	Technology usually has two components: (1) a hardware aspect, consisting of the tool that embodied the technology as a material or physical objects, and (2) a software aspect, consisting of the information base for the tool.
Braun (1998)	Technology encompasses the hardware, the tangible artefacts, used to perform some practical task, as well as the software immediately associated with the hardware.
Betz (1998)	Technology is the knowledge of the manipulation of nature for human purposes.
Griffith (1999)	Technology includes specific tools, machines and/or techniques for instrumental action.
Khalil (2000)	Technology can be defined as all the knowledge, products, processes, tools, methods and systems employed in the creation of goods or in providing services. In simple terms, technology is the way we do things. It is the means by which we accomplish objectives. Technology is the practical implementation of knowledge, a means of aiding human endeavour. Technology is knowledge applied to the creation of goods, provision of services, improvement of our stewardship of precious and finite resources; on a negative note, it can also be applied for destructive purposes.
Ettlie (2000)	Technology refers to the theoretical and practical knowledge, skills and artefacts that can be used to develop products and services as well as their production and delivery systems. Technology can be embodied in people, materials, cognitive and physical processes, plants, equipment and tools. Technology is a system and generalists eventually prevail.
Tellis (2006)	The term technology for a means of solving a problem based on a distinct platform or scientific principle. Subsequently use the term technology synonymously with technological platform or platform.
Burgelman, Christensen and Wheelwright (2009)	Technology refers to the theoretical and practical knowledge, skills, and artefacts that can be used to develop products and services as well as their production and delivery systems. Technology can be embodied in people, materials, cognitive and physical processes, plant, equipment, and tools.

There are various definitions of technology and technology management published in literature, as shown in **Table 2.5** and **Table 2.6** in the following sub-section. Dussauge, Hart and Ramanantsoa (1994) provide a better understanding of technology where they have classified technology into three main categories according to definition of explicit or implicit given to the technology which comprise the following key terms:

(1) *Allusive.* The approaches, which do not explicitly define the word technology. Technology is described as a key factor of success like, for example market share, product quality, and adequate distribution channel.

(2) *Extensive.* Definitions are based on a view of technology as the application of knowledge, which include any form of expertise or sophisticated know-how as technology.

(3) *Specific*. Technology can be seen as being situated between science on the one hand and the commercial products or processes derived from the application of scientific knowledge on the other. All products and processes are thus related to the various technologies they integrate, which in turn are linked to science. In short, technology as the industrial application of science and as the scientific understanding of the process.

As such, Dussauge et al., (1994) further propose that:

Technology is not	**We can speak of technology**
• Individual know-how, craftsmanship or artistic skills, that cannot be formalised and which are improved in isolation, on the basis of experience and not as a result of a systematic research process. For example, there is no technology for fashion and haute couture.	• Only in the context of a business situation; basic scientific research carried out without any clear economic goals is not technology.
• A basic technique, available to all, which can be improved through means other than scientific knowledge (e.g. milling, casting, welding, etc. are not technologies)	• Only when there is production of material objects (goods and services). The design and manufacture of satellites, automobiles, or aircraft draws upon a wide range of technologies, whereas marketing activities are not technology-based.
• Skills or knowledge that do not lead directly to industrial applications, in other words, that do not materialise in manufacturing or product capabilities. Accounting, marketing and financial techniques are not technologies.	• Only if an explicit or even implicit phase of research and development can be identified in the production process. Research and development is the function that defines technology by linking science, technique and production.

Source: Adapted from (Dussauge, et al., 1994, pp. 12-13).

From the above discussions, the researcher concluded that:

As time goes by, the definitions and the understanding of technology in the literature has evolved. This clearly can be seen that at one stage, technology was linked to physical tool (Maack, 1974) cited from (Drejer, 1997), then as a conversion process which transforming input into output (Rousseau, 1979), and the "production process" or the "throughput" of an organisation (Dussauge, et al., 1994), to "brainware" which reflects the knowledge (i.e. know-how) (Betz, 1998; Zeleny, 1986; Zuboff, 1988).

The most recent, technology regards as a system (Ettlie, 2000). Consistent with Braun (1998) and Zeleny (1986) the researcher has synthesised their definitions and proposes that a technology **encompasses the hardware, the tangible artefacts (i.e. machines; tools and techniques), used to perform some practical task, as well as the software immediately associated with the hardware and the brainware (e.g. knowledge-based) with the reasons for using the technology in particular ways.**

Having reviewed the definition and understanding of technology, the researcher believes that it is also necessary for this research to discuss briefly regarding technology development, as the wave of technology movement eventually shapes technology management field as a whole. In summarising the journey of technology development, Freeman and Louca (2001) have divided it into five waves of technologies; (1) water-powered mechanisation of industry; (2) steam-powered mechanisation of industry; (3) electrification of industry, transport, and homes; (4) motorisation of transport, civil economy and war; (5) and computerisation of entire economy. Hatch and Mackey (2002) further update the Freeman and Louca (2001) work by pinpointing five technological revolutions that occurred along these waves: (1) the British Industrial Revolution (cotton, iron, and water power); (2) iron railways, steam power, and mechanisation; (3) steel, heavy engineering, and electrification; (4) oil, automobiles, motorisation, and mass production; and (5) information and communication technology as the current technology wave: computerisation.

In relation, Chanaron and Grange (2007) claim that, *"neither robotics nor the development of new information and communication technologies, especially Internet, have burned themselves out. Key technologies do not replace each other.*

They can perhaps reinforce or complement each other, while pursuing their own diffusion logic". Following from this, the researcher would say that new technology does not make the old technology obsolete (not kill each other), but builds upon it as it develops from one generation to the next (i.e. following the S-curve development).

2.4.2 Defining Technology Management

In order to better able understand technology management field, **Table 2.6** as follows, provides some of definitions of technology management in the literature.

Table 2.6: Definitions of technology management from several authors

Authors	Definitions
Gaynor (1991)	MOT at the academic level implies: developing an understanding as to how all of the technologies of a business can be integrated, directed towards some specific objectives, and optimised with all the other business resources as an example marketing, financial and human resource management must be included.
Gaynor (1996)	Management as a technology can be described as the process of integrating the business unit resources and infrastructure in the fulfilment of its defined purposes objectives, strategies and operations.
Drejer (1997) based on Monger (1988)	Explicitly incorporate mechanisms to deal with management's understanding of new and emerging technologies, organisational and workforce issues, and factors external to the firm.
Chanaron and Jolly (1999)	The management of technology links engineering, science and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organisation.
Khalil (2000)	Management of technology (MOT) is an interdisciplinary field that integrates science, engineering, and management knowledge and practise.

Considering the understanding of technology, there seems to be some conflict, but in general complementarities between scholars. However, there is clearly some disagreement and conflict on how technology management is defined, as the understanding of TM is varies between authors. For example, Gaynor (1996) brings the understanding of TM based on:-

- *Applied Science*. Viewing technology as an applied science referring to the focuses on the issues engaged by engineers and scientists.
- *Academic Discipline*. Technology Management (TM) as an academic discipline that could provide a benefit at some future point in time when

> academia become oriented toward intensive multidiscipline research that possesses some semblance of relevance and is directed toward problem solving and problem finding.

Following on from this, Chanaron and Jolly (1999) and Chanaron and Grange (2007) define technology management (TM) as "*to get the best fit with the firm strategy and best return on the technology portfolio*" and they further extended this view with the term of 'Technological Management' as "*to understand and control the impact of technology on all management functions".*

The researcher believes that the differences in the understanding of TM is based on the fact that technology management is "*a multifunctional and multidisciplinary field that requiring inputs from both commercial and technical function in the firm and synthesis of an academic perspectives"* (Phaal, Farrukh & Probert., 2004). Yet, critics have argued that technology management "*lies in the subject's unusually high degree of interaction with other discipline and this overlap blurs the boundaries of technology management"* (Pilkington & Teichert, 2006).

Looking at the understanding of technology management as a whole, the researcher defines technology management as **a disciplinary field that engages with managing hard aspects of technology (e.g. in the forms of software and hardware) and soft aspects of technology (e.g. knowledge and its application).** In order to further understand the technology management movement and to predict its future, the researcher needs to look how this field has evolved over time. Thus, in doing so, the historical review allows the researcher to establish the patterns of technology management focus, principles, systems, and tools and techniques, which is presented in **Chapter 4** (Analysis and synthesis of the literature).

2.5 Origins and Evolution of Technology Management

The objective of this section is to provide an overview of the origins and evolution of the technology management field. In order to understand how technology management has evolved, the researcher has chosen to start with the Industrial

Revolution which the researcher considers as *'pre technology management'*. Authors such as Ettlie (2000); Crouzet (1977); Freeman and Louca (2001); Heaton (1977); Deane (1977) and Hartwell (1977) consider the main movement of technological development began with the Industrial Revolution in England and the automation of cotton cloth production.

Heaton (1977, p. 31) states that an industrial revolution is the name given to those economic and technological developments, which gathered strength and speed during the eighteenth century, and produced modern industrialism. He adds that the spearheads of the technological advancement in the eighteenth century were iron, cotton and pottery (Heaton, 1977, p. 39). While Wringley (1977, p. 116) likewise states that *"during the late eighteenth century the cotton industry broad development along old lines to a new pitch of perfection, evolving better machinery in both spinning and weaving and extending the use of waterpower into spinning"*.

Consistent with that outlook, Crouzet (1977, p. 144) also highlights that "*in industrial technology the earlier innovation which resulted from the used of coal as a fuel had been supplemented by the great burst of inventive activity of the late seventeenth and early eighteenth century"*.

According to Betz (1993, p. 299; 1998, p. 25) the early phases of the European industrial revolution can be clustered into four groups:

- 1770-1800: The beginning of the Industrial Revolution in Europe was based on the new technologies of steam power, coal-fired steel, and textile machinery.
- 1830-1850: The acceleration of the European industrial revolution was based on the technologies of railroads and steamships, as well as telegraph and coal-produced gas lighting.
- 1870-1895: Basic advances in steel making began the almost total substitution of steel for iron, and there were in innovations around the discovery and refining of petroleum, the invention of electrical power and

lighting technology, the invention of the internal combustion engine, the invention of the telephone, and innovations in the chemical dyes industry.

- 1895-1930: During this period, the automobile and the airplane were invented, and the electron vacuum tube and radio were invented. The first chemically produced plastics were invented, and petroleum became the primary energy source (displacing coal) and a major material source.

Clearly, the early wave of technology development was based on exploration and invention, as mentioned earlier by the work of (Crouzet, 1977; Deane, 1977; Ettlie, 2000; Freeman & Louca, 2001; Hartwell, 1977; Heaton, 1977).

Over time, the 1950s could be considered the turning point of technological development with the emerging focus centred on the product in internal research and development (R&D). This is justified by publications on the R&D program and activities at that time by several authors such as (Anonymous, 1957, 1959a, 1959b; Bruce, 1958; Froman, 1958; Lasser, 1950; Quinn, 1958; Joseph V Sherman, 1952; 1953). In turn, the invention of the transistor in 1947, followed by the integrated circuit in 1959, gave rise to successive generations of new technologies in this era (Burgelman, et al., 2009).

Further, in a classic example, Sherman (1952) outlines the movement towards R&D by companies and industries in the United States, as in the following quotation, "*the research industry has shown amazing growth. Between 1940 and 1950, the number of companies maintaining research laboratories increased from 2,264 to 2,845, and the number of workers employed in these laboratories rose from 70,000 to 165,000*".

All of the above publications suggest the importance of R&D, which also reflects that the technology of the time was closely associated with R&D. In line with this, Drejer (1997) claims that the rationale throughout this period was to provide funding for R&D in order to obtain benefits from the higher levels of performance resulting from the R&D efforts. Coombs and Richards (1993) cited from Edler, Meyer-Krahmer and Reger (2002, p. 150) point out that during this time centralisation and corporate dominance in the funding, ownership and control of R&D, and management thinking was dominated by a greater stress on technology push and R&D spending. As such, this was the time when more effort was put on setting up research laboratories (Anonymous, 1959b). Harrison and Samson (2002, p. 16) based on Gerybadze (1994) suggest that R&D management was initially input-oriented and involved the setting up of many of our modern R&D labs, as well as the establishment of research teams and processes.

Likewise, Gregory (1995) describes that technology management has traditionally focused on product-oriented R&D and assumed a linear model of innovation, starting with science and progressing through technology and design to production (Gregory, 1995, p. 347). This is consistent with an earlier publication by Bruce (1958, p. 21) who claims that research and development employs a greater use of engineering and technical resources, which were implemented in production departments during the transition stage between development and production, in order to produce new or improved products that worked smoothly under normal operating conditions. Along the way, several tools and techniques were used for making decisions, which include technology forecasting and budgeting (Drejer, 1997). Therefore, it fair to say that the product was the pivotal focus during this period (i.e. *How do we develop technology?*).

As time moved on to the 1960s, the key technological developments were in robotics, electronics and electric products (Betz, 1993). In Japan, MITI (the Japanese Government Ministry for Industry Development) began preparing long-term visions of the future for whole industries stretching over a 10-year-plus period. The electronics industry was identified as the main focus for that decade (Harrison & Samson, 2002) based on (Bowander & Miyake, 1993). Following on from that, in 1969, the communications network, ARPANET, was developed, which later became the Internet (Langreth, 1995).

In turn, Mansfield (1989) cited from Betz (1994) used 1961 as the starting point for *'Innovation Management'*, which saw the first sale of an industrial robot based on George C. Dovol's 1954 patent. However, the root of innovation management can be tracked earlier, to the publications of Joseph Schumpeter, who is generally considered the 'father of the innovation theory' (Sundbo, 2001). The work of Schumpeter put emphasis on innovation (Betz, 1998), claiming that innovation represented the driving force of economic development (Schumpeter, 1934, 1942) cited from (Becheikh, Landry, & Amara, 2006). As such, Sundbo (2001) claimed that the definition of innovation can follow Schumpeter (1934) in saying that, *"it is the introduction of new elements or a new combination of elements in the production or delivery of manufactured and service products. Innovation is defined here as the process of transforming the ideas or inventions which are the point of departure into reality. This means the transformation of an invention into a market product, the implementation of new market behaviour, the conversion of new knowledge about the process into a change in that process, and so forth"*.

Consistent with this concept, Frishammar and Horte (2005, p. 252) based on Garcia and Calantone (2002, p. 112) claim that *"an innovation is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention, which leads to development, production and marketing tasks striving for the commercial success of the invention. An invention does not become an innovation until it has been processed through production and marketing and is diffused into the marketplace. Thus, a discovery that goes no further than the laboratory remains an invention"*.

Thus, several tools and techniques that were used extensively during this period, from R&D to production and marketing, such as: project management and evaluation (e.g. Program Evaluation and Review Techniques – PERTs and Critical Part Methodologies – CPM), Delphi forecasting, Theory of Inventive Problem Solving (TRIZ), market research and Cost Benefit Analysis (Drejer, 1997; Pearson, Stratford, Wadee, & Wilkinson, 1996; Yu, 2006).

Clearly, at this time, the technological focus shifted from **product to commercialisation**. The central idea was based on the innovation in product and process, (Utterback & Abernathy, 1975) and how technology can be commercialised (Souder, 1987) cited from (Harrison & Samson, 2002, p. 47) (i.e. *How do we commercialise technology?*).

Following on from this, the 1970s witnessed an economic crisis, which was triggered by the rise in oil prices (Oil Embargo) in 1973 (Dussauge, et al., 1994; Gehani, 1998; Sumanth & Sumanth, 1996). Accordingly, the petroleum oil crisis demonstrated the vulnerability of many industrial companies. The price of petroleum rocketed and quickly reduced the resources available to organisations. Hence, companies could no longer afford to launch their new products on a trial-and-error basis (Gehani, 1998). The consequences of the energy crisis required that a research unit with a long-term orientation be created (Dussauge, et al., 1994).

Accordingly, technological development during this time was referred to by Drejer as *'Technology Planning'*, in which technology can be viewed as a reaction to an environment which is no longer perceived as simple as stable (i.e. the reason for development: increased competition; sustain progress and crisis) (Drejer, 1997). Instead, Chiaromonte (2004, p. 34) insists that, during the 1970s, *"the changes in the relationships among people, strongly fostered by social movements that were active in the environment, the big oil crisis and the increasing application of microelectronic and informatics to manufacturing and management tasks"*.

The progression of technological development continued with the increasing use of robots in industry throughout the mid-1970s - The Institute of Personnel Management (CIPM, 1983). As such, several tools and techniques were implemented and are still being practiced across the world, which is linked to technological planning and project investment. These include scenario forecasting, technology analysis and business planning (Drejer, 1997); Technology Road Mapping (Willyard & McClees, 1987); multi-criteria decision making and lateral thinking (Yu, 2006).

Clearly, the technological focus was centred on **planning,** with the main emphasis on *how we exploit technology.*

In the 1980s technological development was led by advances in computerisation, with the progression in integrated circuit (IC) chips, the innovation of a minicomputer mainframe, mini-supercomputers, engineering workstations and, later, computer networks (Betz, 1994). Thus, according to Burgelman, et al., (2009), this was the period when the digital revolution saw the radical impact of microprocessor technology on computing and communications. The enormous growth in demand for microprocessor-based personal computers created two new technological giants during the mid-1980s— Microsoft and Intel—that spawned entirely new ecosystems, comprising thousands of new high-technology companies, all providing complementary products (Burgelman, et al., 2009). While in Japan, knowledge-intensive industries were identified as the main focus in the 1980s. The Japanese planners have indicated strong interests in lasers, robots and fuzzy logic. MITI was involved in preparing the broad document highlighting the directions for the future and bringing together interested organisations while establishing their commitment for financial support (Bowander & Miyake, 1993).

As such, the term ‘management of technology’ (synonymous with Technology Management) also developed in the mid-1980s, following the proposal of the National Research Council (1987). This was the time when technology management received widespread attention and formally became a disciplinary field (Drejer, 1997).

Following on from that, the growing importance during the 1990s progressed with digital networks for enterprise data communications, which created yet another new giant— Cisco—and spawned a new ecosystem of new high-technology companies. These developments, in turn, sustained the emergence and rapid growth of other major information-processing companies, such as enterprise software giants Oracle and SAP (Burgelman, et al., 2009). The advancement of technology continued with the Internet in the mid-1990s, (Ettlie, 2000; Harrison & Samson, 2002), which also created new ecosystems and literally thousands of new companies, including new types of players such as Netscape, Yahoo!, e-Bay, and Amazon.com (Burgelman, et al., 2009).

Accordingly, this era was referred to by several authors such as (Betz, 1994; Braun, 1998; Chiaromonte, 2004; Drejer, 1997; Dussauge, et al., 1994) as *‘Strategic*

Management of Technology (SMOT)' in which technology can be viewed "*as pervasive forces which must be integrated implicitly and explicitly into core strategic thinking and into every phase of activities at all kinds of companies"* (Gaynor, 1996).

In addition, Shuman and Thamhain (1996) highlight that SMOT emphasis particularly in the strategic incorporation of technology into business for shortening product development life cycles and adopting or exiting technologies faster.

Consistent with this understanding, several tools and techniques were extensively used such as Discounted Cash Flow, Real Option, and Decision trees, which involved the integration of tools and techniques from other disciplines (i.e. finance, decision options and capital budgeting). On top of that, other tools and techniques were developed at this time such as Technology Audit Model (TAM), Model Learning Workplace, GRIPS, and Technology Organisation and People (HITOP). Therefore, during this time, the development of technology was primarily concerned with linking the technology with business strategy (Chiaromonte, 2004). This indicates the focus of technology shifting from **planning** to **integration,** with the main emphasis on *how we develop our capability to manage technology?*

The journey of technology management through to the present day, but dates back to the middle of 1990s, when "*the R&D perspective went beyond the development a new specialisation to constitute a new management paradigm based on the evolution of two concepts: the Management of Technology and Innovation Management. This emerges a new concept of Strategic Management of Technology and Innovation"* (Chiaromonte, 2004, pp. 37-38). Further, Burgelman, et al., (2009) claim that in America during this decade of the nineties, *"the importance of technological innovation for competitive advantage, at the level of both the firm and the country, spurred research and the development of related teaching materials. Literally hundreds of universities, through their schools of engineering or business (or both), introduced or substantially expanded the management of technology and innovation as part of their curriculum and degree programs, as this field became a major topic of broad interest to students, managers, and academics".*

It is clear that the current development of technology management is focused on innovation for every aspect (i.e. open innovation, external innovation and non-technical innovation), as the innovation is expecting to be more entrepreneurial, outwardly focused on new markets, technologies, and business models (Burgelman, et al., 2009). Therefore, from the middle of the 1990s to the present, the focus is on understanding *how we develop our capability to manage technology and innovation?* – Innovation focus.

Table 2.7 summaries the key events in the development of technology management field.

Table 2.7: Important events in the development of technology management

Key Focus	App. Time	Key Events	Key References
How do we develop technology? (Product Focus)	1934 and 1942	The work of Schumpeter puts emphasis on innovation, as Schumpeter claims that innovation represents the driving force of economic development (Schumpeter, 1934, 1942). The books were considered a landmark contribution to the theory of innovation	Becheikh, Landry and Amara (2006); Betz (1998); Sundbo (2001); Schumpeter (1934); Schumpeter (1942)
	1947	The invention of the transistor	Burgelman, Christensen and Wheelwright (2009)
	1950s	The early R&D was input-oriented and involved the setting up of many of our modern R&D labs as well as the establishment of research teams and processes	Gerybadze (1994); Coombs and Richards(1993); Bruce (1958)
		Evolution of industrial sectors as the computer industry evolved	Betz (1994)
		General-purpose stored-program computer was invented in the 1940s and innovated as a commercial product in the 1950s, first by Sperry/ Rand and then by IBM	Betz (1994)
	1959	The invention of the integrated circuit (IC) semiconductor chip in 1959 independently at Fairchild and at Texas Instruments	Betz (1994); Burgelman, et al., (2009)
How do we commercialise technology? (Commercialisation Focus)	1960s	MITI (the Japanese Government Ministry for Industry Development) began preparing long-term visions of the future for whole industries looking over a 10-years plus period. Electronics industries were identified as the focus for that decade	Harrison and Samson (2002); Bowander and Miyake (1993)

	1961	1961 as the starting point for innovation, which was the year of the first sale of an industrial robot based on George C. Dovol's 1954 patent	Mansfield (1989)
	1969	Communications network, ARPANET, developed later becomes Internet	Langreth (1995)
How do we exploit technology? (Planning Focus)	1970s	Economic crisis, which was triggered by the rise in oil prices (Oil Embargo) resulted in a reduction of resources available to organisations High foreign competition in technology-rich products like electronics and automobiles	Chiaromonte (2004); Drejer (1997); Dussauge, Hart and Ramanantsoa (1994); Sumanth and Sumanth (1996) Kanz and Lam (1996)
	Mid – 1970s	Increasing use of robots in industry	The Institute of Personnel Management (1983)
How do we develop our capability to manage technology? (Integration Focus)	1980s	In Japan, knowledge-intensive industries were identified as the main focus in 1980s. The Japanese planners indicated strong interests in lasers, robots and fuzzy logic Motorola used a combination of techniques to combine product planning with technology planning for formulating a technology strategy. Motorola called the outcome of the process a **technology roadmap** for their long-term product development	Bowander and Miyake (1993) Willyard and McClees (1987)
	Mid - 1980s	The term 'management of technology' (also referred to as Technology Management) developed in the mid-1980s, following the proposal of the National Research Council (1987) Digital revolution of microprocessor technology on computing and communications	Chanaron and Jolly (1999); Drejer (1997) Burgelman, et al., (2009)
	1990s	Digital networks for enterprise data communications	Burgelman, et al., (2009)
How do we develop our capability to manage technology and innovation? (Innovation Focus)	Mid 1990s - Future?	Internet technology for conducting business between corporations. Increase in computer aided design and local area networks were most prominent The emergence of a new concept: Strategic Management of Technology and Innovation	Harrison and Samson (2002); Ettlie (2000); Chiaromonte (2004); Chanaron and Grange (2007); Burgelman, et al., (2009)

2.6 Conclusions

At the end of **Chapter 1**, the researcher asked the initial question, **is there any opportunity and potential of bringing quality management and technology management fields together to better understand the potential for synergies, convergences, overlaps and conflicts between these two fields.**

In this chapter, the researcher has identified that both literatures have evolved through time with their ***fundamental focus*** evolving as the literature evolved, and as they evolved, the principles, systems, tools and techniques have changed. Therefore, the researcher would say that as the focus has changed, the principles have also changed and as the principles have changed, the systems, tools and techniques also have changed in Quality Management (QM) and Technology Management (TM).

This observation is consistent with Dale (1994) and several authors' works, such as Besterfield, et al., (2003); Hellsten & Klefsjo (2000); Mahadevan (2010); Mukherjee & Kachwala (2009) that organise their subject of study using the framework of 'principles, systems, and tools and techniques'. The author also believes it is much easier for the reader to understand and follow the framework of 'principles, systems, and tools and techniques', as the terms of the framework itself, comprehensively capturing the field of quality management, and to a certain extent the field of technology management as well. Therefore, it is appropriate to study each evolution of these fields by looking at how the 'focus, principles, systems, and tools and techniques' have evolved, before predicting future quality and technology management, respectively. Thus, in doing so, the historical review allows the researcher to establish the pattern of quality and technology focus, principles, systems, and tools and techniques which will be further discussed in detail in **Chapter 4**.

The evolution of the QM and TM can be classified into eras. From the chronological literature review, it appears that there are five QM eras, which are: (1) Quality Inspection, (2) Quality Control, (3) Quality Assurance, (4) Total Quality Control and (5) Total Quality Management. While it is also appears that there are five eras in TM, which there are: (1) Research and Development, (2) Innovation Management, (3) Technology Planning, (4) Strategic Management of Technology and (5) Strategic Management of Technology and Innovation.

The general understanding of the interaction of focus, principles, systems, and tools and techniques is illustrated in **Figure 2.2** as follows.

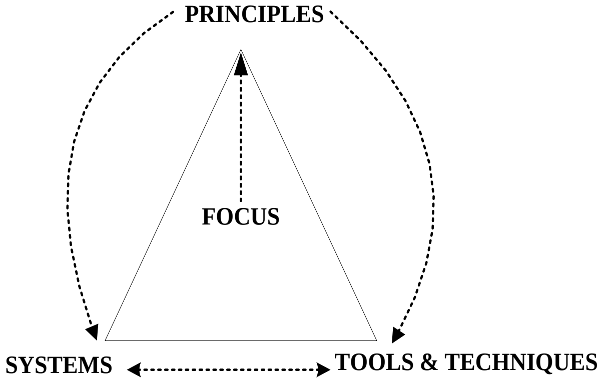

Figure 2.2: A framework for studying the evolution of quality management and technology management

Source: Modified from (Dale, 1994)

Following on from this, ideally the researcher wants to map QM and TM principles against with the eras and look how they evolved. From the literature, nine quality management principles are identified in this study which is consistent with Malcolm Baldridge Model and Business Excellent Model for European Foundation Quality Management (Dahlgaard, et al., 2002; Bank, 2000; ASQ, 2002 and Hakes, 1999), as they are:

1. Continuous Quality Improvement
2. Conformance to Standard
3. Management Understanding
4. Customer Orientation
5. Quality Leadership
6. Quality Involvement
7. Quality Supplier Relationship

8. Process Management
9. System Management

It should be noted that the researcher is not proposing new terms but wishes to distinguish between quality management principles and technology management principles in this study.

The identifying of QM principles can easily be done for QM, but not in TM, as the principles of TM are not clear. There are no agreed principles of TM in the literature. For that reason, the researcher has done a quick consultation with TM experts.

Chapter 3 is about identifying and concluding the principles of Technology Management following from the consultation with TM experts.

CHAPTER 3

Technology Management Principles

3.1 Introduction

This chapter identifies the principles of technology management as a result of consultation with technology management experts in order to elicit the key principles of technology management.

3.2 Method of study

As mentioned in **Chapter 2**, the principles of Technology Management (TM) are not clear in literature, as there is no consensus agreement about these principles. Therefore, there is a need for consultation with TM experts, as the experts in here are referring to the leading scholars (i.e. academic scholar and scholar practitioner) in the area of Technology Management.; a quick opinion survey study has been carried out in order to elicit the key principles in the TM area. The justification of this methodological choice is further underlined in the following **sub section 3.2.1**.

To achieve this, the researcher identified the TM scholars based on their publications in the TM area, which reflects their expertise. Then, the researcher sent an e-mail to them with the following question:

1. Could you list what you believe to be the three (3) main principles of technology management?

The key idea of this question was to invite the scholars to identify what they perceived to be the key principles of TM. Hence, the reason why the author only asking to list three main principles of technology management not less or more because the researcher believes that one or two is far too few. Four and more, tends to be too much and may create an uneasy feeling to the correspondents. So, three is the ideal.

Following on from that, the researcher conducted a face-to-face interview with the founder of International Associate Management of Technology (IAMOT), Prof. Dr. Tarek Khalil during the European Conference on Management of Technology

(EUROMOT) 2009 at Glasgow. The aim of doing this interview was to validate the early findings from the expert opinion survey.

Table 3.1 shows the publication of scholars in TM to justify them as the expert of this field.

Table 3.1: Publication from several scholars

Scholars	Publications
Scholar A	International Journal of Innovation and Technology Management, Journal of R&D Management, Engineering Management Journal, Technovation, Proceedings of the IEEE conference, Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), Proceedings of the International Conference on Management of Technology (IAMOT), Journal of Research Technology Management, International Journal of Technology Intelligence and Planning, Technological Forecasting & Social Change, Proceedings of the Institute of Mechanical Engineers, EurOMA Conference, Process Research in Operations Management
Scholar B	International Journal of Innovation and Technology Management, Journal of R&D Management, Engineering Management Journal, Technovation, Proceedings of the R&D Management conference, Proceedings of the IEEE conference, Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), Proceedings of the International Conference on Management of Technology (IAMOT), Journal of Research Technology Management, International Journal of Technology Intelligence and Planning, Technological Forecasting & Social Change, Proceedings of the Institute of Mechanical Engineers, Process Research in Operations Management
Scholar C	Journal of Management Decision, International Journal of Management, Journal of Small Business and Enterprise Development, Journal of Business Venturing, International Journal of Manpower, International Journal of Educational Management, Journal of Organizational Behavior, Handbook of qualitative research methods in entrepreneurship, European Journal of Innovation Management, International Journal of Environmental Research and Public Health, International Journal of Business and Systems Research, International Journal of Performability Engineering
Scholar D	Journal Research Technology Management
Scholar E	Journal of Product Innovation Management, Text book Technological Innovation, International Journal of Operations and Production Management, Journal of Quality Management, Journal of Strategic Finance, Journal of Management Science, Academy of Management Journal, Journal of Operations Management, Annals of Operations Research, Journal of Decision Sciences Book: Managing Innovation, Managing Technological Innovation, Engineered in Japan, Managing the Design-Manufacturing Process, Manufacturing Strategy: The Research Agenda for the Next Decade, Taking Charge of Manufacturing
Scholar F	Journal of Management Decision, International Journal of Technology Management, International Journal of Product Development, International Journal of Product Lifecycle Management, International Journal of Automobile Technology & Management, Book: Technology Management

Tarek Khalil	Book: Management of Technology: The Key to Prosperity in the Third Millennium; Management of Technology: The Key to Competitiveness and Wealth Creation; Civilization, Modern Technology and Sustainable Development Volume I; Civilization, Modern Technology and Sustainable Development, Volume II; Management of Technology, Sustainable Development and Eco-Efficiency; Management of Technology V: Technology Management in a Changing World; Proceedings of International Conference on Management of Technology

3.2.1 Selecting techniques for expert opinions

Porter, et al., (1991) accentuate that there are a few techniques mainly associated for gathering expert opinion, namely; Survey, Delphi and Nominal Group Process. In definition, Delphi technique is a qualitative method used to systematically combine expert knowledge and opinion to arrive at an informed group consensus on a complex problem (Brown, 1968; Donohoe & Needham, 2009; Linstone & Turoff, 1975; Mannoia & Walkemeyer, 2007). While, Expert Opinion survey is a technique used to synthesize the opinions of experts while accessing uncertainty around those views through conducting an internet-based survey (Donlan, Wingfield, Crowder, & Wilcox, 2010). Nominal Group Technique is a method designed to overcome the unproductive aspects of unstructured, face-to-face meetings and to stimulate creative thinking by a group of experts, as it is used effectively in the early stages of problem definition (Porter, et al., 1991).

In order to elicit the technology management principles, the researcher adopted the survey method under the label of 'Expert opinion survey'. Hence, a small survey was conducted in August, 2008, using leading scholars in the area of Technology Management as participants. As previously mentioned, the purpose was to elicit the key principles of Technology Management. The researcher has identified about nineteen active scholars (academic scholar and scholar practitioner) in the area, and the question was sent through via electronic mail to them. Six experts (leading scholars in the field) participated, responding to the question submitted, at approximately weekly intervals. This research approach is consistent with (Donlan, et al., 2010; Knisely, et al., 2010; Sanjo, et al., 2007) who conducted an internet-based survey used to synthesize the opinions of experts on their studies. As such, an expert opinion survey is practical and much cheaper in relation to the other techniques, as well as minimizing time delays. Similarly, Porter, et al., (1991) also claim that survey is the most common method for soliciting input from group of experts when face-to-face meetings are impractical. Hence, it is relatively quick, reasonably easy, inexpensive and it avoids the negative dynamics of face-to-face meetings (Porter, et al., 1991).

In comparison, the use of an Expert Opinion Survey also has some similarities with Delphi Technique and Nominal Group Technique, where all of them bring a broad range of perspectives and ideas to bear on problem-solving from a comprehensive panel of experts responding to feedback. Thus, these techniques are used to address complexity and uncertainty in an area where knowledge is imperfect, where there are no correct answers or hard facts (Donohoe & Needham, 2009).

Further, the similarity is underlined with the concept that a group of experts is better than one expert when exact knowledge is not available (Donohoe & Needham, 2009). Donohoe and Needham (2009) also put forward their view that participants are stakeholders and/or subject matter 'experts'; selection criteria is pre-determined whereby the findings represent synthesis opinion and not a statistically significant result. Another similarity is that, the Delphi communication with the individual panel members is typically via mail or faxed but there is also evidence of electronic mail being used to distribute the questionnaires (Amos & Pearse, 2008).

On the other hand, it is also clear that Delphi and Nominal Group Techniques required more rounds of process in order to reach a consensus. This is suggested by several publications as highlighted below:

"The typical Delphi requires a group of relevant expert experts to respond to an iterative series of written questionnaires (called rounds) interspersed with summarized information and feedback of opinions derived from earlier responses to stimulate thinking mailed or faxed to each respondent individually with the objective of the group reaching consensus" (Amos & Pearse, 2008).

In short, (Amos & Pearse, 2008) put forward their view that there are five characteristics underlined within Delphi technique, as summarised as follows:

1. Its focus on researching the future or things about which little is known
2. Reliance on the use of expert opinion
3. Utilising remote group processes
4. The adoption of an iterative research process
5. The creation of a consensus of opinion

Likewise, there are six steps suggested by (Porter, et al., 1991) in using Nominal Group of Process, which they are:

1. Silent (Nominal) Idea Generation.
2. Group Round-Robin Listing of Factors
3. Discussion and Clarification of Listed Factors
4. Silent (Nominal) Individual Written Voting on Priorities
5. Discussion of Voting Results
6. Final, Silent (Nominal), Individual Written Voting

So, in the author's opinion, the author cannot claim that he has fully adopted Delphi or Nominal Group Technique, as the way that this research was conducted was well suited under the label of Expert Opinion Survey. Thus, the researcher has conducted the research this way (i.e. using Expert Opinion Survey), due to the practical reasons based on whom he could access, and feasibility. Further, to compensate the limitation of this approach, the researcher also adopted a face-to-face interview with Professor Tarek Khalil, the founder of International Association Management of Technology (IAMOT) and coupled this with technology management literature in order to validate the early findings from the expert opinion survey.

3.3 Findings

Table 3.2 summarises the responses from the scholars, which were contacted.

Table 3.2: Findings from several scholars

Scholars	Principles of Technology Management
Scholar A	1. The evolutionary nature of technological development (S curves etc). 2. The need to link technology to the market to realise value (as done through innovative products and services and supported by techniques such as roadmapping). 3. Technological know-how as a key resource in an organisation (where technology needs to be identified, selected, acquired, exploited and protected).
Scholar B	1. To incorporate technological issues into business thinking, decisions and processes
Scholar C	1. High employee involvement and motivation. 2. Leadership support. 3. Clear norms for exploration.
Scholar D	1. To develop and exploit the firm's capacity for innovation. 2. To acquire, develop, and allocate an organisation's resources where technology is a resource. 3. Understanding one's innovative capabilities and using those capabilities to leverage business.
Scholar E	1. Sorry, no such principles exist
Scholar F	1. I think that there is a book to be written on such principles and I have no idea who could do the job. Not me for sure.
Tarek Khalil	1. Exploration and technology development maybe is one of the principles, as you need to do exploration for new technology. 2. Technology as a whole, can be product or process where the improvement requires knowledge, which encompasses know-how. From know-how, one can make improvements in technology. 3. Technology know-how creates the value.

The findings are interesting as they suggest that there are areas with some degree of consistencies and common ground. From the findings of opinion survey and face-to-face interview, which were previously described in **Table 3.2** together with the TM literature, the following sections discuss what the key principles of TM might be.

Ofari (1994, p. 149) claims that technology development requires financial resources, conducive economic conditions, relevant administrative support, organisations which can apply new technology, a suitable physical infrastructure and a supportive culture. Mahmood and Rufin (2005) further suggest that technology development is "*a process of simultaneously managing flows of resources and ideas. It involves the replacement of existing technology by one that is more advanced*". In line with this, Magnusson and Johansson (2008) claim that technology development focuses primarily on establishing new functionality and understanding underlying phenomena related to new technologies where technology development bears the promise of making product development more predictable and easier to rationalise.

In addition, a new technology development process is in fact a learning process in which new knowledge is created (Manaikkamakl, 2007, p. 18) and the importance of technology development has also been addressed by authors such as (Herps, Mal, & Halman, 2003; Hoecht, 2004). Consistent with this, Scholar A claims that the TM principle can be seen as the evolutionary nature of technological development (S curves etc), while Scholar C insists that clear norms for exploration is the key principle. Further, Khalil suggests that exploration and technology development maybe is one of the principles, as one need to do exploration for new technology.

Based on the above discussion, this suggests that **technology development** is one of the key principles of TM.

Technology improvement can be described in a manner of process of improvement (i.e. intellectual know-how) and the result of improvement (i.e. capability). Accordingly, Thomas, Barton and John (2008, p. 173) note that technology improvement refers to enhance the performance of the technology by using advanced engineering analysis techniques to continuously improve technology capability and reliability. This corresponds with Scholar A who claims that technological know-how is a key resource in an organisation (where technology needs to be identified, selected, acquired, exploited and protected). In line with this, Khalil deems that technology as a whole, can be product or process where the improvement requires knowledge, which encompasses know-how. From know-how, one can make improvements in technology. Consistent with this, Scholar D also points out the importance of acquiring, developing, and allocating an organisation's resources where technology is a resource. Further, Scholar D also highlights the need to understand one's innovative capabilities.

Based on these discussions, these reflect that **technology improvement** (i.e. process improvement and result of improvement) is one of the key principles of TM.

Technology leadership is referred to the technological direction specifically in providing leadership in technology areas (i.e. how leadership drives the technology)

(Babcock & Morse, 2002), with the success or failure of the programs rests in part on the role of opinion leaders (Rogers, 2003). In addition, as noted by Jong and Hartog (2007, p. 44), leadership is referred to as the process of influencing others towards achieving some kind of desired outcomes where shared leadership enhances people's involvement and motivation to generate ideas and to strive for successful implementation (Jong & Hartog, 2007, p. 52). Concise with this, Scholar C suggests that leadership support is the key element in TM principle.

Based on the above discussion, this suggests that **technology leadership** is one of the key principles of TM.

Technology partnerships/supplier participation reflect the interaction and involvement of supplier participation and partnerships, where in certain circumstances suppliers are partners in forming the alliances and collaborations in order to handle technologies activities/issues amongst themselves (i.e. partners, suppliers and producers). This relationship reflects the extent to which both individuals/firms are committed to the relationships, and that they find it to be productive and worthwhile (Giannakis, 2007). The importance of suppliers/partnerships has been addressed by authors such as (Babcock & Morse, 2002; Carr, Kaynak, Hartley, & Ross, 2008; Machado & Manaus, 2007).

Further, Li and Vanhaverbeke (2009, p. 844) regard supplier relationship as one of the most important industrial relationships and the participation of suppliers are categorised in terms of different functional areas, namely product design, timely delivery, raw materials supplied, process design, policy equipment/technology/maintenance, and marketing (Kayis & Kara, 2005, p. 745). As such, problems associated with technological uncertainty can be mitigated by greater information sharing through supplier participation (Karandikar & Nidamarthi, 2006, p. 1047). In line with this, Scholar C further informs that high employee involvement and motivation is the key principle in TM. Therefore, this also suggests that supplier participation/partnerships in a wider context, which includes the participation and involvement of employees, is one of the key principles of TM.

Based on these discussions, this suggests that **technology partnerships/supplier participation** is one of the key principles of TM.

Technology pioneering reflects that technology comes in the form of the pioneers that take the risks to develop and commercialise a new technology to the market, thereby developing the potential to earn profits (Gehani, 1998, pp. 7-8). Several studies have also discussed the importance of pioneering; to be the forefront as the front-runner or technological breakthroughs (Ali, 1994, p. 48) and this relates pioneers to gain market share advantages and are likely to be the market leaders (Benedetto & Song, 2008; Garrett, Covin, & Slevin, 2009; Li & Vanhaverbeke, 2009).

Based on the above discussion, this suggests that **technology pioneering** is one of the key principles of TM principles.

According to Gaynor (1991), technology management is actually "*the practice of integrating technology strategy with business strategy in the company. This integration requires the deliberate coordination of the research, production, and service functions with the marketing, finance, and human resource functions of the firm*". In addition, Gaynor further accentuates that managing technology into the business requires that organisations to integrate the technologies of all of the functional departments into the business, as this integration implies bringing things together under the same umbrella (Gaynor, 1991).

The importance of integration has been addressed by authors such as (Capuano, Gaeta, Ritrovato, & Salerno, 2008). In line with this concept, as noted by Drejer (2000, p. 126), "*integration is a making of a whole or entire where the whole to be the result of integration is, in this context, technology management*". As such, this reflects that the area of Technology Management has truly become interdisciplinary which emphasises the need to study how to integrate different disciplines and perspective, and also implies its diversification and integration (Clayton M. Christensen, Anthony, & Roth, 2004 ; Drejer, 1997). This corresponds with Scholar

B who claims that TM needs to incorporate technological issues into business thinking, decisions and processes. Consistent with this, Scholar D insists that understanding one's innovative capabilities and using those capabilities to leverage business is the key principle.

Based on these discussions, this suggests that **technological integration** is one of the key principles of TM.

Technological value reflects that technology as value focuses on providing value creation of technology with regard to different contexts (e.g. economy, society). This makes it possible to tell whether a technology is ‘bad or good’ or even ‘better or worse’ than other technologies (Drejer, 1997) based on (Maack, 1974). Khalil also accentuates that technology know-how creates the value. Thus, value creation under rapidly evolving markets underlines the need for innovation, flexibility, and speed, pressure for new applications, unique solutions (Prahalad & Krishnan, 2008, p. 185).
Additionally, Laitinen (2004) suggests that “*value creation in technology firms is largely based on their ability to innovate, that is the ability to assimilate and exploit new knowledge”.* In line with this, Scholar A states that there is the need to link technology to the market to realise value, as done through innovative products and services and supported by techniques such as roadmapping. Consistent with this, Scholar D points out that to develop and exploit the firm's capacity for innovation is the key principle of TM.

Based on the above discussion, this suggests that **technological value** is one of the key principles of TM principles.

Technology standards are associated with reducing uncertainty by controlling variety; enhancing competition by clearly defining what is required to serve a market (information); constituting markets by defining the relevant aspects of products (Iversen, Oversjoen, & Lie, 2004; Tirole, 1988), which are accepted and shared within a community (Chituc & Azevedo, 2007; Crargil, 1989).

The importance of standard, further has been discussed by authors such as (David, 1995; Wonglimpiyarat, 2004) from the issues of product and industrial standards to closed and open standard (Baldwin & Woodard, 2008; Eisenmann, Parker, & Alstyne, 2008; Iansiti, 2009). Accordingly, Wonglimpiyarat (2004, p. 248) suggests that "*the ability to establish the innovator's own technology as standard provides a route to competitive advantage. This is because standards can help create network externality effect through compatibility. Also, standards help tie in the customers since standards allow the creation of a base of compatible users, making it difficult for any competitors to capture on an individual or niche basis"*. To a certain extent, standardisation of a system adds value by making systems interchangeable. As a consequence, the competitive basis shifts to performance and functionality.

Based on the above discussion, it is fair to say that **technology standards** are one of the key principles of TM.

Based on the previous discussion, the researcher concludes that there are **eight key principles of Technology Management,** which are:

1. Technology Development
2. Technology Improvement
3. Technology Leadership
4. Technology Partnerships/Supplier Participation
5. Technology Pioneering
6. Technological Integration
7. Technological Value
8. Technology Standards

3.4 Conclusions

Table 3.3 identifies the key technology management principles together with the references that led the researcher to the text descriptions.

Table 3.3: Key concept from several authors

TM Principles Identified	Descriptions	References
Technology Development	Involves the replacement of existing technology by one that is more advanced by establishing new functionality and understanding underlying phenomena related to new technologies.	Herps, et al., (2003); Hoecht (2004); Magnusson and Johansson (2008); Mahmood and Rufin (2005); Ofari (1994); Manaikkamakl (2007); Scholar A; Scholar C and Tarek Khalil
Technology Improvement	Enhancing the performance of the particular technology by continuously improving technology capability and reliability (i.e. process improvement and result of improvement – the end result).	Gehani (1998); Thomas, et al., (2008); Scholar A; Scholar D and Tarek Khalil
Technology Leadership	The technological direction specifically in providing leadership in technology areas (i.e. how leadership drives the technology).	Babcock and Morse (2002); Rogers (2003); Jong and Hartog (2007) and Scholar C
Technology Partnerships/ Supplier Participation	The interaction and involvement of suppliers in forming the alliances and collaborations in order to handle technology activities/issues amongst themselves (i.e. partners, suppliers and producers).	Babcock and Morse (2002); Carr, et al., (2008); Karandikar and Nidamarthi (2006); Li and Vanhaverbeke (2009); Machado and Manaus (2007); Giannakis (2007); Kayis and Kara (2005) and Scholar C
Technology Pioneering	Pioneer that takes the risks to develop and commercialise a new technology to the market, and this allows pioneers to gain market share advantages, thereby developing the potential to earn profits.	Ali (1994); Benedetto and Song (2008); Garrett, et al., (2009); Gehani (1998); Li and Vanhaverbeke (2009); Voss (1989)
Technological Integration	Emphasises the need to integrate different disciplines and perspectives, and also implies its diversification and integration (i.e. incorporating technology, enterprise business and strategy).	Drejer (1997); Drejer (2000); Capuano, et al., (2008); Christensen, et al., (2004); Scholar B and Scholar D
Technological Value	Focuses on providing value creation of technology with regard to different contexts (e.g. economy, society). This makes it possible to tell whether a technology is ‘bad or good’ or even ‘better or worse’ than other technologies. Thus, value creation under rapidly evolving markets underlines the need for innovation, flexibility, and speed, pressure for new applications, unique solutions.	Drejer (1997) based on Maack; Laitinen (2004); Pralahad and Krishnan (2008); Scholar A; Scholar D and Tarek Khalil
Technology Standards	Associated with reducing uncertainty by controlling variety; enhancing competition by clearly defining what is required to serve a market (information); and defining the relevant aspects of products, which are accepted and shared within a community.	Tirole (1988); Baldwin and Woodard (2008); Chituc and Azevedo (2007); Crargil (1989); David (1995); Eisenmann, et al., (2008); Iansiti (2009); Iversen, et al., (2004); Wonglimpiyarat (2004)

Having reviewed the historical quality and technology management literature and also identified the principles of these two fields, this brings to a new question of '**how have quality management and technology management principles, systems, tools and techniques evolved and how they relate to each other in the future context?'.** Thus, the researcher will look at the eras in more detail in the next chapter, in order to see the changes of quality management and technology management in these eras.

Next, in **Chapter 4**, the researcher discusses the evolution of the literature on quality and technology management in terms of focus, principles, systems, and tools and techniques, before predicting the transition of future context, which reflects the predicted movement of future changes respectively.

CHAPTER 4

In-depth Literature Review

4.1 Introduction

This chapter presents an in-depth literature review of quality management and technology management fields with a view to understanding how each of these fields has developed or evolved over time, as illustrated below in **Figure 4.1**: Quality Management and Technology Management merger.

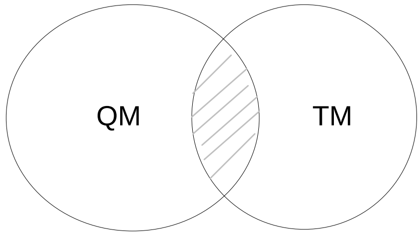

Figure 4.1: Quality and Technology Management merger

This literature review is presented with a particular emphasis on *how* the development of each field tracked or related in terms of focus, principles, systems, and tools and techniques. Accordingly, this historical review allows the researcher to project the potential future trends for each of these fields.

4.2 Literature Review Approach

As mentioned in **Chapter 2**, the researcher has identified that the evolution of quality management and technology management fields over time can be mapped using Dale's framework (Dale, 1994) of principles, systems, and tools and techniques. In order to describe these two fields using this framework, definitions of the framework terms are stated for clarity.

According to Slack, et al., (2006) principles are *"the core ideas that describe how operations behave, how they can be managed, and how they can be improved. They are not immutable laws or prescriptions that indicate how operations should be managed, nor are they descriptions that simply explain or categorise issues*". In this research, the researcher defines principles as the **core ideas or the fundamental ways of thinking in performing things.**

Betz (1998, p. 39) defines the concept of a system as "*to look at a thing, an object, with a view to seeing it as a totality, displaying change, and encompassed in an environment"*. Additionally, American Society for Quality - (ASQ, 2002, p. 8) define a system as "*a set of interrelated or interacting processes*". Consistent with this, the researcher has synthesised their definitions and proposes that a system is **a set of interrelated or interacting processes with a view to seeing it as a totality, displaying change, and encompassed in an environment.**

Borrowing the definition from American Society for Quality (2002), a tool is defined as *"a device used to help accomplish the purpose of a technique"*. In line with this and the work of (Phaal, Farrukh, & Probert, 2004), the researcher defines a tool as **something that facilitates the practical application of a technique** and a technique is **a structured way of completing part of a procedure.**

4.3 Principles, Systems, and Tools and Techniques of Quality Management

As mentioned in **Chapter 2**, quality management evolution can be divided into five specific eras, which are: (1) Quality Inspection (QI), (2) Quality Control (QC), (3) Quality Assurance (QA), (4) Total Quality Control (TQC), and (5) Total Quality Management (TQM). It should be noted that the terms used here are based on the *emerging focus* throughout the evolution of quality management. Consequently, the focus is believed to drive the principles, systems, and tools and techniques in the development of each quality era. **Chapter 2** allowed the researcher to identify nine quality management principles, these are:

1. Continuous quality improvement
2. Conformance to standard
3. Management understanding
4. Customer orientation
5. Quality leadership
6. Involvement

7. Quality supplier relationship
8. Process management
9. System Management

Each era will now be discussed according to the framework introduced earlier.

4.3.1 Quality Inspection (QI) Era

During this period, quality was associated with inspection (Dahlgaard, et al., 2002; Garvin, 1988, p.5). Accordingly, "*at one time inspection was thought to be the only way of ensuring quality"* (Dale, 2003, p. 22). Further, Dale (2003) based on BS EN ISO 9000 – British Standards Institute (2000) defines quality inspection as the *"degree to which a set of inherent characteristics fulfils requirements".* It is clear this period was focused around **products**.

Principles of Quality Inspection

Along the path of Quality Inspection era, the primary principle of quality was stressed as sorting good from bad, with continuous quality improvement based on the corrective action basis. The idea was to commit solely to conformance to product standards. The management understanding during this time laid on specialisation of labour that means every worker has his own task. This principle can be traced back to when Henry Ford came introduced the implementation of task separation and mass production manufacturing. The leadership style at this time was about command. In fact, the management understanding towards quality was very shallow with the assumption that quality was a subordinate to cost, and customers were seen as a necessary evil, as evidenced by the infamous quotation, *"Any customer can have a car painted any colour that he wants so long as it is black"* (Batchelor, 1994) based on (Ford, 1922). Therefore, the consumers bought what was available as the economy was dominated by the producers.

Systems

In the author's opinion, it is fair to say that the Ford mass production system was the main comprehensive system around during the QI era (Batchelor, 1994; Womack, et al., 1990). This system combined all elements of a manufacturing system, consisting of people, machines, tooling, infrastructure (factory) and products, which worked together in a continuous system for manufacturing the Model T automobile (Batchelor, 1994). Therefore, the production system could be considered as the formal system that emerged at this point of time.

Tools and techniques

Inspection technique and the moving assembly line could be considered as the key tools and techniques in this period, as inspection was used to grade the finished product and a moving assembly line made it possible to produce products in great numbers (Dahlgaard, et al., 2002; Dale, 2003; Foster, 2001; Garvin, 1988; Roth, 1996; Womack, et al., 1990).

4.3.2 Quality Control (QC) Era

Continuing from the quality inspection era, the next movement was about quality control (Dahlgaard, et al., 2002; Dale, 2003; Garvin, 1998). As a consequence, previous work by quality gurus such as Fredrick W. Taylor, Walter Shewhart, G.S Radford, Deming and Ishikawa stressed inspection activities that are linked more formally to quality control. Indeed, **product** was still the key focus during this era (i.e. *product focus*).

Principles of Quality Control

In this Quality Control era, one of the main ideas in continuous quality improvement was the use of statistical tools to control process output (ASQ, 2002; Garvin, 1988; Martinez-Lorente, et al., 1998). However, at this time, quality improvement was limited to corrective action (i.e. finding and fixing problems). In terms of conformance to standard, the idea was solely about meeting quality standards (i.e. product standard). Clearly, the ideas during this time were still on specialisation of labour and the assumption that quality was secondary to cost. Yet slowly and gradually, systematic documentation and the review of product specifications, inspection procedures and responsibilities emerged and became the central ideas during the QC era.

In the principle of leadership, command and control were the centred idea during this era (Bititci, Garengo, Dorfler, & Nudurupati, 2008; Zuboff, 1988). The products produced were depended on what the producers supplied. As it was not based on market demands customers had no freedom to select. The product quality was based on the perspective of the producer without the customers involvement. Process management was still fragmented at this time. Dale (2003, p. 23) claims that, *"there was lack of creative and systematic work activity, with planning and improvements being neglected and defects being identified late in the process"*. For instance, the principle of system management occurred and it was about the product. The emphasis of the system was about the understanding of the isolated cause and effects in product quality.

Systems

In this period, no new system emerged with the production system still dominating during this era.

Tools and techniques

Several tools and techniques, such as Statistical Quality Control (SQC), inspection link to quality control, sampling Acceptable Quality Levels (AQL), Average Outgoing Quality Limit (AOQL) and Total Preventive Maintenance (TPM) emerged and made an impact during the QC era (ASQ, 2002; Garvin, 1988; Martinez-Lorente, et al., 1998; Nakajima, 1988; Richardson, 1997). It is clear that statistical analysis became so influential played a big part in the movement of quality control during this period.

4.3.3 Quality Assurance (QA) Era

According to Dale (2003, pp. 24-25) quality assurance is about a "*prevention-based system which improves product and service quality, and increases productivity by placing the emphasis on product, service and process design"*. While (Ishikawa, 1985, p. 75) defines quality assurance as a means to *"assure quality in product so that a customer can buy it with confidence and use it for a long period with confidence and satisfaction"*. Accordingly, in this era, the focus of quality management shifted from **product to process**.

Principles of Quality Assurance

The principle of continuous quality improvement during this time seemed to be rather systematic but fragmented improvement, with the agenda of quality improvement shifting from corrective action to preventive action. Thus, the quality conformance had changed from product to process standards in the operational system. On top of that, from a management understanding view, emphasis was on multi-skilled labour and not only about specialisation of labour as in previous times. Hence, the management understanding brought the idea of systematic documentation and review of quality policies, procedures and responsibilities (e.g. Quality Management System). This was a proactive approach rather than the reactive approach in the QC era. By this time, the principle of customer orientation had evolved to understanding customers' requirements through capturing, documenting and reviewing them as part of the quality process. The changes in quality principles of leadership became more systematic, where leadership was driven by the quality system orientation (leadership in the system) with some elements of control (i.e. decision-making and rectifying problems). In spite of that, the quality principles of involvement and supplier relationships were slow to emerged. At this stage, controlled involvement and controlled partner relationships had occurred. For example, staff in the organisation could be involved in quality programs and activities but still under the control of management. The same case applied with supplier relationships.

In short, involvement and supplier relationships became the issues and key ideas in quality development. Looking at the principle of process management and system management the transition happened from fragmented to integrated process control in the quality process; as there was recognition of quality as a process in itself. While system management underline the understanding of simple causes and effects in the process and discrete proven process (the quality system and practices were likely to have met as a minimum requirement). This suggests that the principle of the system management was not fully applied until the adoption of a systems approach during the Quality Assurance era.

Systems

Quality Assurance era could be considered as the focal point for the formal development of quality management systems. For example, the Deming Model was the comprehensive measurement system of quality standards developed during this time in 1951 (Dahlgaard, et al., 2002; Foster, 2001; Garvin, 1988). The release of British Standard (BS) 5750 and International Organisation for Standardisation (ISO) 9000 series were the formal quality systems that made a mark during this time (ASQ, 2002; Bank, 2000; Dahlgaard, et al., 2002). See also British Standards Institute (BSI) at www.bsigroup.com and International Organisation for Standardisation at www.iso.org. In line with this, Total Preventive Maintenance (TPM), which was primary focused on techniques for maintenance of assets (i.e. product and machine maintenance), evolved to Total Productive Maintenance (TPM) that focuses on productivity of entire system (including man, machine, method etc) (Nakajima, 1988; Richardson, 1997). This means that the Preventive Maintenance, which was very much process focused, became system focused by moving to Total Productive Maintenance (i.e. shifting to system focus).

Tools and techniques

During this era, the revolution of tools and techniques rapidly occurred. Plan-Do-Check-Act (PDCA) was extended to become Plan-Do-Study-Act (PDSA) (ASQ, 2002; Garvin, 1988). Further, Cause and Effect Diagram, Failure Mode and Effect Analysis (FMEA), Reliability Engineering, Statistical Process Control (SPC), Kaizen, Kanban, Jidoka and Just-In-Time (JIT) were among the tools and techniques that emerged at this era (Bank, 2000; Bounds, et al., 1994; Dahlgaard, et al., 2002; Garvin, 1988; Gower, 1990; Imai, 1986; Louis, 1997; Martinez-Lorente, et al., 1998).

4.3.4 Total Quality Control (TQC) Era

Total Quality Control era reflected the development of *quality systems* orientation in the context of quality management development. In some cases, there was an overlap in the context and application of tools and techniques, as this was the time when the focus of quality management shifted from **process to systems.** Ideally, the boundaries of quality had extended to a bigger scope, which completely covered the entire process embedded in the system. As noted by Feigenbaum (1961), *"total quality control is an effective system for integrating the quality development, quality maintenance and quality improvement efforts of the various groups in an organisation so as to enable marketing, engineering, production and service at the most economical levels which allow for full customer satisfaction".*

Principles of Total Quality Control

The changes in the principles of continuous quality improvement can be seen as it became much more systematic and manageable. The researcher would describe this as systematic managed continuous improvement. Accordingly, the line of thinking improved with managed prevention and improvement. In terms of conformance to standard, it was about conformance to a systematic improvement standard which was managed by a team (i.e. Quality Control Circle and Problem Solving Group). As such, the management understanding evolved with the understanding of the need of multi-skilled and cross-functional teams working to improve quality on a daily basis. Team working became central to ensuring quality. This understanding included managing systematic use of tools and techniques, and facilitating objective and structured management. Occasionally, this was the time where quality was perceived as a project driven journey. On top of that, the idea of customer orientation transformed to customer satisfaction by fulfilling and exceeding customers' requirements. The principle of leadership changed to be more participatory where the leaders (i.e. top management) encouraged all staff to take responsibility for quality and managed the involvement of workers (e.g. Quality Control Circle and Kaizen activities). At this time, the issues of managing involvement and partnership relationships emerged in a quality context. Further, process management evolved and became more systematic, while system management dealing with the understanding of complex causality in the operational processes.

Systems

The changing from quality assurance to total quality control era includes changes in quality systems deployment. The systems that emerged in this period were Toyota Production System (TPS), ISO 9000 revision 1994, Ford Q1 System, QS 9000, ISO

14000, OHSAS 18000 and TickIT (Morris, 2004; Stamatis, 1996; Womack, et al., 1990). See also International Standard for Organisation at www.iso.org, International Occupational Health and Safety Management at www.ohsas-18001-occupational-health-and-safety.com and TickIT at www.tickit.org. This reflected the progression of new standards in TQC era. In short, quality standards became the most dominant systems at this point.

Tools and techniques

Several tools and techniques that made the headlines during this time were Quality Loss Function, Quality Functional Deployment (QFD), Poka Yoke, Quality Control Circle (QCC), 7 Quality Tools (i.e. Pareto Analysis; Fish Bone Diagram; Stratification; Check Sheet; Histogram; Scatter Diagram and Control Chart), Benchmarking, Lean tools and techniques, and Single Minute Exchange of Die (SMED) (ASQ, 2002; Bank, 2000; Garvin, 1988; Ishikawa, 1985; Shingo, 1985; Womack, et al., 1990; Zairi, 1994).

4.3.5 Total Quality Management (TQM) Era

Total quality management is about the cooperation of everyone in an organisation and associated business processes to produce value-for-money products and services, which meet and exceed the needs and expectations of customers (Dale, 2003). Today, the quality focus is not solely about the systems but includes people, so the focus now is about **people in organisation** (i.e. *people focus*)

Principles of Total Quality Management

In TQM era, the evolving principles of quality are centred on the people. For instance, the quality principle of continuous improvement has evolved to become more systematic and habitual. This means that improvement is not only about managing and rectifying mistakes or problems, but becomes habitual for prevention and improvement.

During this era, conformance to standard is about conformance to systematic improvement standard, which has become habitual for the workers. From the perspective of management understanding, the transformation of ideas happened, where multi skilled cross-functional teams and the use of tools and techniques for facilitating objective and structured management have become the norm among the employees. Along with this, the principle of customer orientation transformed from customer satisfaction orientation to customer delight (i.e. exceeding customer expectation) mainly in service dominant culture, which is about adding value to customers, business, life etc. The principle style of quality leadership centred on coherent leadership with excellence mindset. Leadership goes beyond participation to a mindset of excellence. In terms of involvement, it has extended to a bigger scope, encompassing all levels and the habitual involvement of suppliers and partner in continuous quality improvement activities. By this time, process management has evolved where processes are managed as an integrated system, and system management has evolved to become a complex system, concerning the understanding of causalities in business processes including operational, managerial, support and human factors.

Systems

During this time, the quality systems that emerged and impacted on the quality management field was the Malcolm Baldrige Model, Investors in People (IIP), EFQM Excellence Model, ISO 9001 revision 2000, Lean concept (i.e. Lean Manufacturing) and ISO/TS 16949 standards for automotives (ASQ, 2002; Bank, 2000; Dahlgaard, et al., 2002; Mason, 1997; Womack, et al., 1990). See also International Automotive Task Force at www.iatfglobaloversight.org.

Tools and techniques

The tools and techniques that make a mark during this time include Design of Experiments (DOE), 5S (i.e. Seiri, Seiso, Seiko, Seiketsu and Shisuke) and Six Sigma, which later capturing the TQM philosophy and becomes the philosophy itself (Eckes, 2005; Foster, 2001; Imai, 1986).

In summary, borrowing from the work of, (Slack, et al., 2006, p. 376):

"Quality was achieved by inspection – screening out defects before customers noticed them. Then the 'quality control' (QC) concept developed a more systematic approach to not only detecting but also solving quality problems. 'Quality assurance' (QA) widened the responsibility for quality to include functions other than direct operations, such as Human Resources, Accounting and Marketing. It also made increasing use of more sophisticated statistical quality techniques. TQM included much of what went before but developed its own distinctive themes, especially in its adoption of a more 'all-embracing' approach".

Figure 4.2 using cycle curve to illustrate the evolution of quality management from Quality Inspection (QI) to 'Quality Management 2.0' (the predicted future of quality management) and **Table 4.1** provides the brief summary of this evolution of quality management field organised into the focus, principles, systems, and tools and techniques framework.

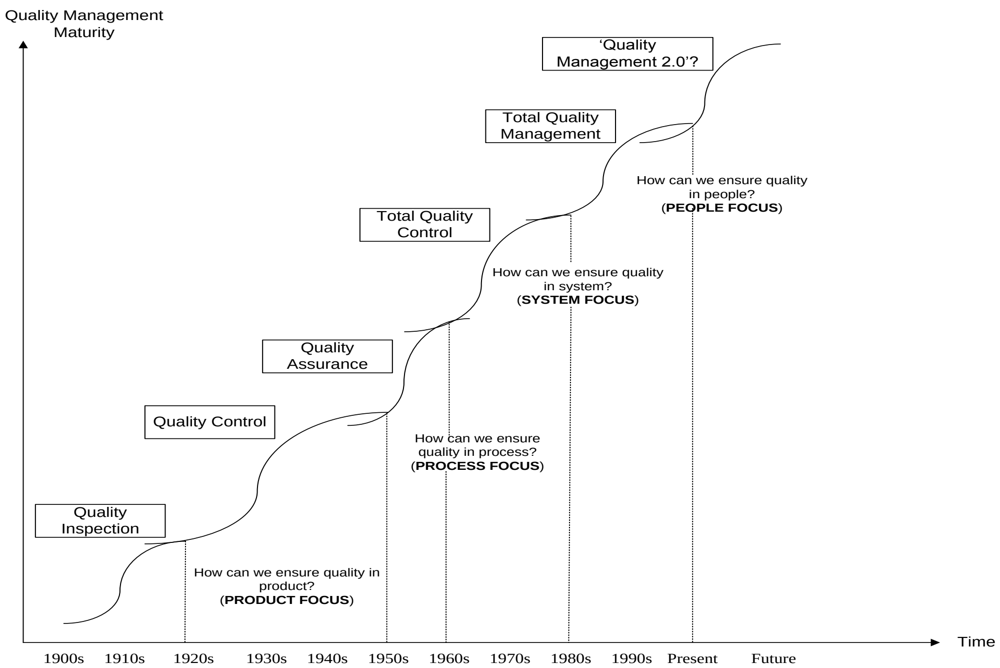

Figure 4.2: The evolution of Quality Management

Table 4.1: The origins and the evolution of quality management from Quality Inspection (QI) to Total Quality Management (TQM)

Dimension	**Quality Inspection (QI)**	**Quality Control (QC)**	**Quality Assurance (QA)**	**Total Quality Control (TQC)**	**Total Quality Management (Business Excellent)**
Approximate Timings	1900s ~ 1920s	1920s ~ 1950s	1950s ~ 1980s	1960s ~ 1990s	1980s ~ present
Key References	Garvin (1988, p. 5); Foster (2001, p. 44) - Fredrick W. Taylor Batchelor (1994, p. 22); Womack, Jones, & Roos (1990, p. 26) - Henry Ford Garvin (1988, p. 5) - G.S Radford Dahlgaard, et al., (2002); Garvin (1988); Dale (2003); Foster (2001) – Inspection Roth (1996); Womack, et al., (1990) – Moving assembly line	ASQ (2002, p. 29) - Walter Shewhart ASQ (2002, p. 20) - Deming Garvin (1988, p. 9) - Bell Laboratories Dahlgaard, et al., (2002, p. 90) - Ishikawa ASQ (2002); Garvin (1988); Martinez-Lorente, Dewhurst & Dale (1998) – Statistical Quality Control (SQC) Garvin (1988) – Acceptable Quality Level (AQL) and Average Outgoing Quality Limit (AOQL) Nakajima (1988); Richardson (1997) - Total Preventive Maintenance	Bound, Yorks, Adam & Ranney (1994, p. 58); Gower (1990, p. 193) - Failure Mode Effect Analysis (FMEA) Garvin (1988), Martinez-Lorente, Dewhurst & Dale (1998) and Bank (2000) - Statistical Process Control (SPC) Nakajima (1988) and Richardson (1997) - Total Productive Maintenance (TPM) Imai (1986); Dahlgaard, et al., (2002, p. 306) – Kaizen Gower (1990, p. 453) and Louis (1997, p. 21) – Kanban Dahlgaard, et al., (2002) – Jidoka Gower (1990) - Taiichi Ohno and Just-In-Time (JIT) Garvin (1988, p. 198); Foster (2001, p. 36); Dahlgaard, et al., (2002, p. 23) - Union of Japanese Scientists and Engineers (JUSE) and Deming Prize	Feigenbaum (1961) - Total Quality Control Garvin (1988, pp. 189,198) - Genba-To-QC Ishikawa (1985); Bank (2000); ASQ (2002, p. 4) - Ishikawa Womack, et al., (1990)) - Toyota Production System (TPS) ASQ (2002) - Taguchi and Quality Loss Function Garvin (1988, p. 198); Bank (2000); Zairi (1994, p. 43) - Quality Functional Deployment (QFD) Nikkan Kongyo Shimbun (1988) – Poka Yoke Ishikawa (1985) - Seven Quality Tools and Quality Control Circle (QCC) Shingo (1985) - Single Minute Exchange Die (SMED) Crosby (1979) - Crosby Zero Defects and “The Absolutes"	Foster (2001) - Total Quality Management Philosophy Foster (2001, p. 49) - Genichi Taguchi and DOE Imai (1986) – 5S Crosby (1984) – 14 Points ASQ (2002); Bank (2000) - Malcolm Baldrige National Quality Award Womack, et al., (1990) - Toyota and Lean Manufacturing Eckes (2005, p. 12) - Motorola & GE and Six Sigma Mason (1997, p. 1) - National Training Task Force and Investors In People Dahlgaard, et al., (2002, p. 23) – EFQM, Business Excellence Model International Organisation for Standardisation - ISO 9001

			Garvin (1988, p. 12); Bank (2000); ASQ (2002, p. 22); Juran (1951) - Juran Quality Control Handbook Bank (2000); www.bsigroup.com - British Standards Institute (BSI) ASQ (2002, pp. 4,30,32); (Bank, 2000); www.iso.org - International Organisation for Standardisation, Geneva	Bank (2000) - Xerox Corporation and Benchmarking Womack, et al., (1990, p. 159) - Ford system Q1 Stamatis (1996, p. 76) - Daimler-Chrysler, Ford & General Motor and Quality System (QS 9000) International Organisation for Standardisation; Morris (2004) - ISO 14000 International Occupational Health and Safety Management at www.ohsas-18001-occupational-health-and-safety.com – OHSAS 18000 series DISC TickIT (1992) – TickIT	Revision (2000) and ISO 9001 Revision (2008) IATF (2002); see also www.iatfglobaloversight.org - ISO/TS 16949
Focus	Product	Product	Process	System	People in Organisation
Principles: **Principle 1 Continuous Improvement**	Sorting good from bad Corrective Action	Use of statistical tools to control process output Corrective Action	Systematic but fragmented improvement Preventive Action	Systematic managed continuous improvement Managed prevention and improvement	Systematic and habitual continuous improvement Habitual prevention and improvement
Principle 2 Conformance to Standard	Conformance to product standard	Conformance to product standard	Conformance to process standard in the operational system	Conformance to systematic improvement standard (Managed)	Conformance to systematic improvement standard (Habitual)

Principle 3 Management Understanding	Specialisation of labour Quality subordinate to cost -	Specialisation of labour Quality subordinate to cost Systematic documentation and review of product specifications and inspection procedures and responsibilities	Multi-skilled labour - Systematic documentation and review of quality policies, procedures and responsibilities (e.g., Quality Management System)	Multi-skilled and cross-functional teams (Managed) - Managed systematic use of tools and techniques facilitating objective/structured management	Multi-skilled cross-functional teams (Habitual) - Habitual use of tools and techniques facilitating objective/structured management
Principle 4 Customer Orientation	Customer is a necessary evil	Customer has no choice	Understanding customers requirements through capturing, documentation and review of customer requirements	Customer satisfaction by fulfilling and exceeding customers requirements	Customer delight in service dominant culture adding value to customers, business, life etc.
Principle 5 Leadership	Command	Command and control	Systems and control	Participatory	Coherent leadership with excellence mindset
Principle 6 Involvement	No involvement	No involvement	Controlled involvement	Managed involvement	Habitual involvement at all level
Principle 7 Supplier Relationships	Adversarial arm’s length (i.e. no relationship)	Adversarial arm’s length (i.e. no relationship)	Controlled partner relationships	Managed partner relationships	Habitual involvement of partner in continuous improvement activities
Principle 8 Process Management	No recognition of the process	Fragmented	Integrated process control	Systematic process management	Processes are managed as an integrated system

Principle 9 System Management	No system thinking or understanding	Understanding isolated cause and effects in product quality Product	Understanding simple causes and effects in the process Discrete proven process	Understanding complex causality in the operational processes Operational processes	Understanding complex system causalities of business processes including operational, managerial, support and human factors Complex system causalities
Systems	Mass Production System	Mass Production System	Deming Model BS 5750 Quality Management series ISO 9000 Standards Total Productive Maintenance (TPM)	Toyota Production System (TPS) ISO 9000:1994 Ford Q1 System QS 9000 ISO 14000 OHSAS 18000 TickIT	Malcolm Baldrige Model Investors In People EFQM Excellence Model ISO 9001:2000 Lean concept ISO/TS 16949 ISO 9001:2008
Tools & Techniques	Inspection Moving assembly line	Statistical Quality Control (SQC) Inspection link to quality control Sampling Acceptable Quality Levels (AQL) Average Outgoing Quality Limit (AOQL) Total Preventive Maintenance	Plan-Do-Check-Act (PDCA) Extend PDCA to become Plan-Do-Study-Act (PDSA) Cause and Effect Diagram Failure Mode Effect Analysis (FMEA) Reliability Engineering Statistical Process Control (SPC) Kaizen Kanban Jidoka Just-In-Time (JIT)	Quality Loss Function Quality Functional Deployment (QFD) Poka Yoke Quality Control Circle (QCC) 7 Quality Tools (Pareto Analysis, Fish Bone Diagram, Stratification, Check Sheet, Histogram, Scatter Diagram, Control Chart) Benchmarking Lean tools and techniques Single Minute Exchange of Die (SMED)	Design of Experiments (DOE) 5S Six Sigma

4.4 Principles, Systems, and Tools and Techniques of Technology Management

As mentioned in **Chapter 2**, technology management evolution can be divided into five specific eras, which are: (1) Research and Development (R&D), (2) Innovation Management (IM), (3) Technology Planning (TP), (4) Strategic Management of Technology (SMOT), and (5) Strategic Management of Technology and Innovation. It should be noted that the terms used here are based on the *emerging focus* throughout the evolution of technology management. Earlier in **Chapter 3**, the researcher has identified and presented eight technology management principles by considering the feedback from active scholars in technology management field. These principles are:

1. Technology Development
2. Technology Improvement
3. Technology Leadership
4. Technology Partnerships/Supplier Participation
5. Technology Pioneering
6. Technological Integration
7. Technological Value
8. Technology Standards

Each era will now be discussed according to the framework introduced earlier.

4.4.1 Research Development (R&D) Management Era

During this era, technology was associated with internal research and development (R&D) (Assimakopoulos, 2007; Edler, et al., 2002; Gerybadze, 1994; Harrison & Samson, 2002). According to Drejer (1997, p. 254) the *"R&D management school is the first school of Management of Technology, the rationale was to provide funds for R&D (targeted to appropriate developments) in order to harvest benefits from the higher levels of performance resulting from the R&D efforts".* He adds that, "*R&D in essence is the coordination of the activities of many different individuals in order to optimise the corporation's technological performance against that of its competitors"* (Drejer, 1997). The key focus at this time centred on the development of the **product** (i.e. *product focus*) through managing R&D resources, i.e. input – oriented.

Principles of R&D

In the principle of technology development, technology S-curve was considered as the starting point in R&D management era (Drejer, 1997). Further, Drejer (1997) claims that, *"the S-curve phenomenon implies that the higher accumulated investments are in developing a given technology, the higher is the performance of that technology. This has strong implications for top management, since the development of any particular technology is very expensive but will result in higher performance".*

In turn, Christensen (1992) calls the technological S-curve, *"a theoretically captures the potential for technological improvement resulting from a given amount of engineering effort which varies over time".* Likewise, other authors such as (Burgelman, et al., 2009; Khalil, 2000; Yu, 2006), also view the important of S-curve in relations to resources and product performances. **Figure 4.3** below illustrates the S-curve dimension.

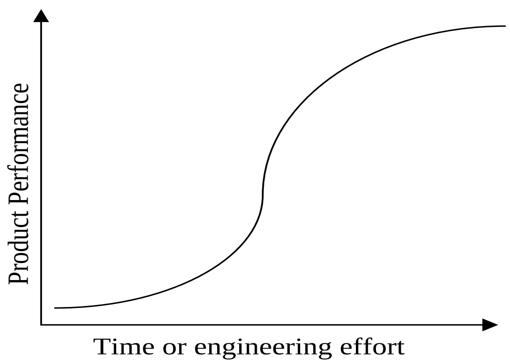

Figure 4.3: Illustration of the Technology S-curve dimension
Source: Adopted from Christensen (1992)

At this point, the core idea behind technology development involved managing resources to create new technology in order to develop new products; technology improvement was about improving assets and infrastructure (e.g. building internal laboratories). The result of improvement could have been assumed stable, simple and expanding (Drejer, 1997). In the author's opinion, it is clear that the leadership direction was to provide funds for R&D with the aim of building and creating new technologies (Drejer, 1997; Wang & Kleiner, 2005).

From the point of view of technology partnerships and supplier participation, this era was about supplying materials and services only, and one in which the relationship between customers and suppliers was relatively simple. Technology seemed to be fragmented, as there was no integration within the organisation. At this time, technological value centred on the performance of the final product, while the technological standard was based entirely on the standard of technology in the product (i.e. product standard). This was due to the fact that, product selection (i.e. technology push), including the value given, was totally one-sided, as the production of technology came typically from technical specialists, such as scientists and engineers (Harrison & Samson, 2002), with no concern for market forces (Khilji, Mroczkowski, & Berstein, 2006).

Systems

Throughout this era, the researcher would say that the system was based on *curiosity driven R&D projects*. This involved trial-and-error experimentation (i.e. the exploration of new technologies and products), and was characterised by the limited effectiveness of the applications resulting from the technology compared with the resources allocated for its development. Thus, it also includes the difficult yet crucial task of selecting research projects closely related to the strategic plan of the firm (Braun, 1998).

Tools and techniques

The key tools and techniques involved for making decisions were budgeting and technology forecasting techniques that were closely aligned with project management as the pillar of support for R&D projects (Drejer, 1997; Drejer & Riis, 1999; Khalil, 2000).

4.4.2 Innovation Management (IM) Era

According to Braun (1998) innovation management consists of many related tasks. This includes dealing with the new product through the turbulent and chaotic early stages of production and providing the marketing team with all the necessary information in order to promote the product effectively. In short, the innovation management concept is based on the interactive connection between products, manufacturing and organisational processes, which is largely incremental and continuous (Chiaromonte, 2004). At this time, the focus was on **commercialisation** driving innovation throughout the entire firm (i.e. *commercialisation focus*).

Principles of Innovation Management

In this period, the principles of technology slowly changed and progressed. Accordingly, invention could be considered the starting point for the innovation management era (Ettlie, 2000) where the core idea involved managing resources in order to create new commercial opportunities through technology advancement. The process of improvement was used to enhance innovation, and find more effective solutions for the problems encountered. The consequence of such improvements was change; however, it was a form of change that remained predictable (Drejer, 1997).

Drejer (1997) claims that, *"in the Innovation Management school of thought, innovation becomes a much broader concept not only in terms of technological life-cycle but also in term of the corporation in which the innovation process includes all the function from R&D to manufacturing and marketing. Within this management school, technological changes are assumed to be rather unpredictable but still predetermines according to the technological S-curve. Thus according to S-curve, technologies are dynamic, they have life cycles and they go through different stages of maturity".*

Further, Ettlie (2000) states that "*innovation can be thought of as another term for the process whereby new and improved products, processes, materials and services are developed and transferred to a plant and/or market"*. In a classic article, Utterback and Abernathy (1975), explain that innovation is a new technology or combination of technologies which has been introduced commercially to meet a user or market need. As such, Ettlie (2000, p. 38) based on Roberts (1988), claims that innovation is composed of two parts, (i) the generation of an idea or invention, and (ii) the transformation of that invention into a business application. In short, he equates innovation as:

Innovation = Invention + Exploitation

Source: (John E. Ettlie, 2000)

In principle, throughout this period, leadership direction was transformed, with greater emphasis placed on the innovation process, which included all functions, from R&D to manufacturing and marketing. Clearly, thinking had shifted from creating and developing new products to the commercialisation of these products. In terms of technology partnerships and supplier participation, suppliers provided added value through materials and services, with some additional participation at the operational level, including the provision of specific information, and providing advice and guidance as demanded by the customers. From the perspective of pioneering technology, this era placed a greater emphasis on applying technology in order to improve efficiency. Therefore, at this point, it could be said that the 'demand/market pull' occurred, which reflects the idea that solutions and product selection originate from the market (Becheikh, et al., 2006), as the market is the source of ideas for directing R & D (Assimakopoulos, 2007). It is clear that this era moved into 'market pull', which means understanding customer requirements, market trends, and also having a greater awareness of what competitors are offering, and then translating that knowledge into specifications for innovative products and services, which require technological developments in order to be produced (Harrison & Samson, 2002).

By this point, the integration of technology within organisations was more explicitly linked to business strategy, rather than viewed as separate. On top of that, the idea stressed the importance of technology as a means of adding value to economics, where the cost was the major concern. This idea advanced the argument that, on the one hand, technology has been a major driver of economic growth (Shuman & Thamhain, 1996), and on the other hand, that the contribution of technology to economic growth is a generally accepted and acknowledged fact (Gaynor, 1991). In principle, technological standards had transformed the standard in the technology of process (i.e. process standard).

Systems

The researcher would describe that the fundamental principles of innovation management indicated that the system in place during this period was based on *commercially-driven R&D projects*, managing innovation throughout the entire organisational structure (Assimakopoulos, 2007; Becheikh, et al., 2006; Wang & Kleiner).

Tools and techniques

The tools and techniques required to support these principles in this era were based on project management and evaluation, market research, Delphi forecasting, Theory of Inventive Problem Solving (TRIZ) and Cost Benefit Analysis in progressing from R&D to production and marketing (Brent, 1996; Drejer, 1997; Pearson, et al., 1996; Whitney, 2007; Yu, 2006).

4.4.3 Technology Planning (TP) Era

Continuing from the innovation management era, technology planning "*comes close to technology strategy as it means planning the range of production technologies and the range of products the firm should aim for in the longer term. This involves scanning the horizon for new technologies and observing rivals very closely. It is in the selection of innovations and in the selection of technologies that technology assessment is of particular importance*" (Braun, 1998). In this era, the focus of technology management shifted from **commercialisation to planning,** with the scope of technology management extended to managing technology across the company in order to strengthen operations (Drejer, 1997).

Principles of Technology Planning

Based on the principle of technology development, technology planning was considered a reaction to the environment (e.g. economic crisis and increased competition), which was no longer perceived as simple and stable (Drejer, 1997). This development consists in an end-to-end planning approach to R&D, innovation and the commercialisation of stand-alone technology. Consequently, each technology was treated as a stand-alone strand, and the technological development process and procedure treated as a project. This reflected a more rigid coupling of business needs with development activities, and led to better project management (i.e. managing the project management process), planning and monitoring systems, which were subsequently implemented (Assimakopoulos, 2007).

By this time, the improvements in technology had shifted from improving innovation to improving core competencies and managing the technological project within a confined manageable realm. In some cases, the result of improvement could be changing and discontinuous (Drejer, 1997). Also, in relation to leadership direction, greater emphasis was placed on technology planning, in which the project or company aims were considered as the ultimate rules of thumb. As such, in terms of technology partnerships and supplier participation, the changes in supplier relationships became more participatory in terms of accomplishing what had been planned and requested by the customers. In fact, the relationships included playing a role in team operations, although, at this point, it was rather rigid and constrained. As a consequence, suppliers were made to comply with the planning tasks within operations, (i.e. time, quality, quantity) in order to establish customers/suppliers relationships between business and technology activities.

The thinking behind pioneering technology during this time was about establishing manageable elements in order to produce the technology (masterpieces), as the time in which technology arrived on the marketplace was of the utmost importance. This was due to the fact that R&D and marketing were more in step with the situation of ‘push or pull or push-pull combinations’ (Assimakopoulos, 2007). As a result, the integration happened at the R&D/marketing interfaces (Assimakopoulos, 2007). As such, it could also be said that technology was rigidly integrated within business and corporate-wide managerial operations.

Meanwhile, in terms of technology standards, this era was not only concerned with product or process standards, but also with industrial standards. For example, firms that were first to implement a particular new technology were likely to shape the development of that new technology in later years. The mover/pioneer - the so-called ‘technological leader’ - often set the standard, which at a later stage became the industrial standard, namely, the standard which followers had to conform to, or attempt to circumvent. In addition, the leader created a favourable corporate image for itself, and, from the outset, occupied a dominant position on the experience curve that characterised the new technology (Dussauge, et al., 1994).

Systems

The researcher would describe that the fundamental principles of technology planning indicated that the *technology life cycle* became the driving system in dealing with the various stages and complexity of projects at this time. Accordingly, the technological life cycle curve is intended to describe the progress of a technology from its introduction to its maturity and discontinuation (Bowen, 2004). Thus, it demonstrates that the selection of technologies must be carefully planned and executed, taking into consideration as many system variables as possible (Sumanth & Sumanth, 1996) and used to indicate the possible future capabilities for the technology in question (Bowen, 2004).

Tools and techniques

Tools and techniques such as scenario forecasting, technology analysis and business planning, Technology Roadmapping, multi-criteria decision making and lateral thinking, were the biggest influences during this era in making decision regarding technological planning and project investment (Dissel, Farrukh, Probert, & Hunt, 2006; Drejer, 1997; Phaal, et al., 2004; Willyard & McClees, 1987; Yu, 2006).

Summarising this era, Gaynor (1991) claims that technology planning consist of *"evaluating investments in technology for the financial, business, resource risks in the context of the specific business and within limitations and constraints of the business unit. The differences on evaluating and justifying must be recognised - flexible process and evaluating appropriate projects that support the strategy".* Gaynor also highlights the essences of technology planning as:

- Analysing investments in technology
- Selecting and evaluating projects
- Developing business unit technology plans
- Reducing total project time

4.4.4 Strategic Management of Technology (SMOT) Era

Specifically, Drejer (1997) stresses that the label of technology-based strategic management could characterise all approaches to MOT, since the approaches are all '*strategic*' in some manner. This integrated MOT reflects an attempt to integrate technology and business issues within strategic management (Badawy, 1998; Gaynor, 1996). At this time, the focus of technology management shifted from **planning to integration,** through the management and integration of technology with other aspects of business.

Principles of Strategic Management of Technology

In principle, during this era, technology could be viewed as the starting point for the Strategic Management of Technology (SMOT) (Drejer, 1997). Similarly, during this period, the development of technology was concerned with establishing an integrated approach to technology management, in order to integrate the various strands of technology with the business life cycle (Assimakopoulos, 2007; Wang & Kleiner, 2005). The impetus behind this movement was the involvement of strategic management in technology management, which fosters high chances of one technology being produced to fulfil the company's overall objectives and aims. This is consistent with Assimakopoulos's work where he put his views forward on SMOT, as integrating technical change with business development, as well as an integrated model where technology represents an integral and vital element of corporate strategy (Assimakopoulos, 2007).

Along with this movement, improvements in technology evolved to improve intellectual properties in gaining a competitive advantage. Likewise, Jambekar and Pelc (1996) suggest that in order for companies to gain a competitive advantage, "*a company must include building and developing knowledge resources to leverage improved long-term financial performance. This imposes new requirements and creates new opportunities for individuals, teams, and organisations for managing technology. Development, adoption, and improvement of a new technology involve several types of knowledge and skills, such as technological knowledge, economics, and organizational dynamics, as well as technical-engineering and systems integration skills*". In short, companies that are better able to reach the market first with a breakthrough may gain a major and sustainable competitive advantage (Burgelman, et al., 2009). Accordingly, the results of improvements during this period were considered as changing, discontinuous, unpredictable, with new dimensions emerging (Drejer, 1997).

At this point, the technology leadership emphasis is on connecting other resources (e.g. human resources) and organisational measures to be integrated with technological development. In other words, to optimise the allocation of financial and human resources to the research and innovation process of the firm (Chanaron & Grange, 2007; Gaynor, 1991). Technology partnerships and supplier participation have transformed into strategic and operational partnership (Assimakopoulos, 2007; Wang & Kleiner, 2005). Ideally, these relationships are established to ensure long-term cooperation in which the suppliers fully participate in the operations, and are responsible for the success and failure of them. Assimakopoulos (2007) further describes this period as one involving a parallel development with integrated development teams, strong upstream supplier linkages, and close coupling with leading-edge customers.

From point of view of pioneering technology, in the author's opinion, this thinking suggests that companies need to be at the forefront of technology in order to gain a competitive advantage (Assimakopoulos, 2007; Jambekar & Nelson, 1996). Also, this era, witnessed the integration of strategy, technology and business development within organisations (Assimakopoulos, 2007; Wang & Kleiner, 2005). Further, this was the period when technology was essential in adding value to business, with technology providing the knowledge base for the subsequent value-adding transformations of business, which directly affected profitability (Betz, 1998).

In addition, this also underlined the rapidly changing marketplace requirements, and the high pace of business change, characterised by globalization, higher consumer expectations, greater competitive pressures, and shorter process cycle time structures to meet (Lowe, Scandura, & Von Glinow, 1996). Consequently, organisations needed to be equipped technologically in order to meet their strategic objectives and create new opportunities, as well as respond to the threats created by the market environment and activities of their competitors (Harrison & Samson, 2002). In short, in the author's opinion, this movement linked technology to market orientation in order to realise value. At the same time, the marketplace created the balance of acceptance in relation to new technology, in creating the technological value (i.e. it was the market that decided the new technology).

In terms of the technology standard, by this time, the standard in technology had slowly grown and was moving towards the public standard (standard in technology open to the public). An example of this took place in 1984, when the Free Software Foundation (FSF) and a Copyleft, called General Public License, emerged out of a project to develop and freely distribute GNU, a UNIX-like operating system (See GNU at: www.gnu.org/). The Copyleft stipulated that users could copy the program, modify it, and distribute the original or modified versions. All programs that used source code under the GPL became in their entirety freely available under the GPL itself, even if parts of the program consisted of proprietary software (i.e. public can make changes to the technology standard, as it becomes as a public standard). The fact is that the authors of the Copyleft wanted to spread freely into the community (waive the intellectual properties rights applies on the technology) (Burgelman, et al., 2009).

Systems

It is fair to say that *integrating technology life cycle within the business life cycle* was the most prominent system during the SMOT era. Collectively, this system drove the planning of the development or acquisition of production technologies and of products with the right technological features, to fit in with the general strategic plan of the firm (Braun, 1998). Similarly, Bulgelman, et al., (2009) also point out that integrating technology and strategy should, therefore, be a dynamic process, and it requires that the firm understands the dynamics of the life cycle of the various technologies it employs.

Tools and techniques

The key tools and techniques around this development were Discounted Cash Flow, Real Option, Decision trees, Technology Audit Model (TAM), Model Learning Workplace, GRIPS and Technology Organisation and People (HITOP) (Dissel, et al., 2006; Garcia-Arreola, 1996; Majchrzak, 1996).

Summarising this era, Gaynor (1996) claims that, *"in recent strategic management research, practise and writing advocates integrating technology and business strategies with an associated view of technologies as primary supports for improved products and processes. Typically define strategies as composed of resource allocation plans, policies, procedures, programs, and projects for such objectives, reflecting an implicit assumption of technologies as separable (although interacting), distinct and not always central. While useful, they still lack a view of technologies as pervasive forces, which must be integrated implicitly and explicitly into, core strategic thinking and into every phase of activities at all kinds of companies".*

Further, Badawy (1998, p. 3) suggests that, *"the management of technology is the practise of integrating technology strategy with business strategy, contributing to enlarging the conventional definition when stating that such integration requires the deliberate coordination of R&D, manufacturing and other service functions".*

4.4.5 Strategic Management of Technology and Innovation Era

Strategic Management of Technology and Innovation reflects the latest era in the technology management field (Burgelman, et al., 2009; Chanaron & Grange, 2007; Chiaromonte, 2004). At this time, the focus of technology management shifted from **integration to innovation,** with the scope of technology management expanded to include the management of non-technological innovation (e.g. Business Process Re-engineering) and robust innovation (i.e. external innovation) along with the use of technology for competitive advantage.

Principles of Strategic Management of Technology & Innovation

Today, it seems that technology development is about the Strategic Management of Technology and Innovation coming together and capturing the innovation, not only in relation to the technology itself, but also in relation to the strategies, methodologies, techniques, and plans of actions (Burgelman, et al., 2009; Wang & Kleiner, 2005). From the perspective of technological improvement, such improvement is about enhancing intellectual property, and maximising the outcome, even though there may be scarcity and limitations in relation to some resources. Thus, this is a time where resources are becoming increasingly rare and expensive, and where competition is fiercer and more global, even in the field of research and development (Chanaron & Grange, 2007). Hence, in the author's opinion this reflects the high level of competition, which can potentially cause technological failure not only after being placed in a market place, but also in the embryonic stage of development.

At present, the leadership direction has further extended its view with the key idea about attaining the company's ultimate objectives with macro (i.e. Politics; Economics; Social; Technical; Legal and Environment) challenges and high uncertainties, both internally and externally. With respect to innovation as a source of sustainable development (Chanaron & Grange, 2007), it is clear that the principle of technology partnerships and supplier participation has transformed the suppliers into partners for operations, who hold higher responsibilities and significant roles in the success or failure of the operations (Wang & Kleiner, 2005). To a certain extent, suppliers become the experts in terms of providing the latest information and guidance, sharing, and building mutually sustainable relationships between themselves and their customers. Hence, the symbiosis between these two parties is established.

In terms of pioneering technology, the researcher would describe that collaborative technology, the breakthrough of uncertainties and sustaining a competitive advantage, are the driving forces for this principle (Chanaron & Grange, 2007). As such, technological integration happens in the context of integrated strategic management of technology with innovations, hence towards a fully integrated parallel development (Assimakopoulos, 2007). It is the focal point in the refinement of strategy and technology itself, where technology is used to enhance competitiveness.

In turn, the technological value can be seen as the marketplace that creates the balance of acceptance in relation to new technology (market that decides the new technology) or vice versa, where technology would potentially create the market demand (Hoyle, 2007; Wang & Kleiner, 2005). In saying this, companies must compete differently to win the business of customers who are over-served by functionality. This can be achieved through innovations that facilitate speed to market, and the ability to customise features and functions in response to the needs of customers in even smaller market niches, along with greater efforts to compete with these dimensions of speed, flexibility, and customisation (Burgelman, et al., 2009).

In addition, more recently, the technology standard has transformed to become a brand standard, as a standard becomes the brand name. One example of this, XML, was originally developed at World Wide Web Consortium (W3C) and MP3 – originally developed by Thomson - are standards and marketed as a brand. MP3 – the digital audio format has even become a consumer brand (Iversen, et al., 2004). See also XML at www.xml.org and W3C at www.w3.org.

Systems

The system of the current era could be considered as *systems integration with business model (i.e. networking model)* (Assimakopoulos, 2007) with greater emphasis on innovation activities. These involve strong links with "*leading-edge customers (customer focus at the fore-front of strategy), strategic integration with primary suppliers including co-development of new products and linked CAD systems. Horizontal linkages, including joint ventures, collaborative research groupings, collaborative marketing arrangements, etc. Emphasis on corporate flexibility and speed of development (time-based strategy). Increased focus on quality and other non-price factors*" (Assimakopoulos, 2007).

Tools and techniques

During this period the key tool and technique involves a Technology Assessment/Audit - a procedure used to comprehensively access the complex social and economic implications surrounding new technologies (Salina & Salina, 2007). Further, Salina and Salina (2007) point out that Technology Assessment is most profitable when combined with an interdisciplinary approach, such as Life Cycle Assessment (i.e. assessment of the impact of products during their life cycle, from production to disposal) to evaluate the influences that are measurable, and risk analysis for potential and also uncertain aspects.

In summarising this era, Chanaron and Grange (2007) suggest that the central ideas underpinning the Strategic Management of Technology and Innovation are:

- Satisfying the needs or the demand for new products and services (demand pull)
- The scientific and technical creation of new applications (technology push)
- Knowledge needed in win-win collaboration whether it is for knowledge creation, diffusion or transmission
- Playing an active part in elaborating new business processes for new products and services, which will inevitably call for new functioning rules, renewed forms of organisation and new managerial behaviour

Figure 4.4 using cycle curve to illustrate the evolution of technology management from Research and Development (R&D) Management to 'Technology Management 2.0' (the predicted future of technology management), **Table 4.2** provides a brief summary of this evolution of technology management in relation to the focus, principles, systems, tools and techniques framework.

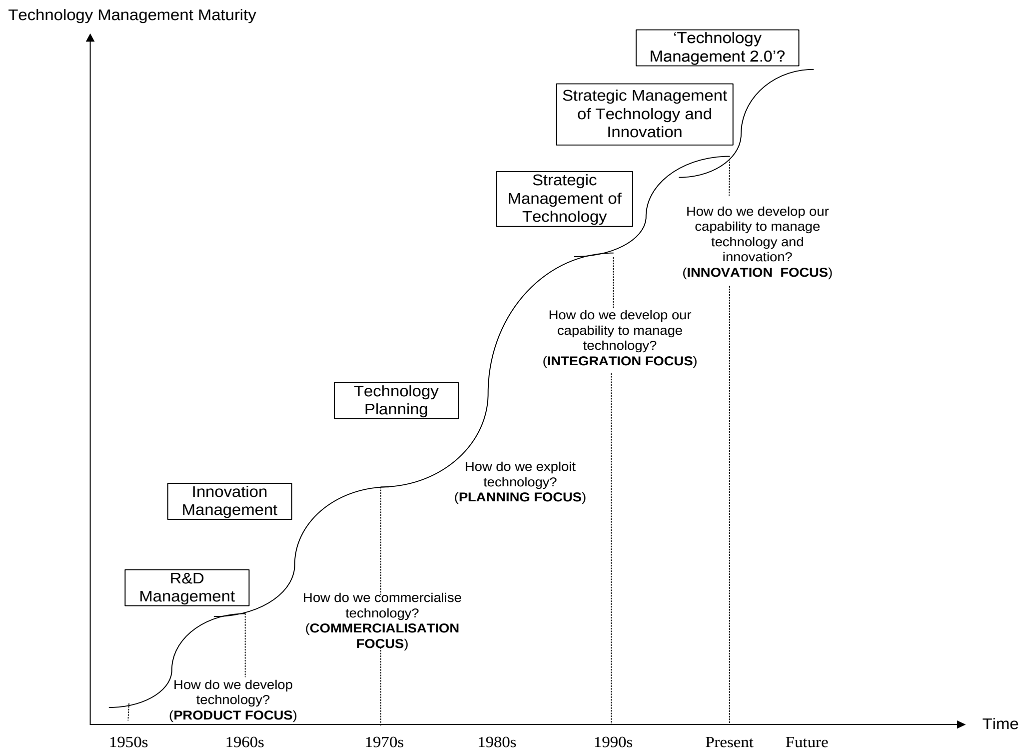

Figure 4.4: The evolution of Technology Management

Source: Modified from (Chiaromonte, 2004; Drejer, 1997; Wang & Kleiner, 2005)

Also**, Figure 4.4** above illustrates that each era/individual concept within this Technology Management is building upon each other (i.e. compounding effect). For example, Innovation Management includes R&D Management, Technology Planning includes Innovation Management, Strategic Management of Technology includes Technology Planning, Strategic Management of Technology and Innovation includes Strategic Management of Technology.

Table 4.2: The origins and the evolution of technology management from R&D to Strategic Management of Technology and Innovation

Dimension	Research & Development (R&D)	Innovation Management (IM)	Technology Planning (TP)	Strategic Management of Technology (SMOT)	Strategic Management of Technology and Innovation
Approximate Timings	1950s ~ 1960s	1960s ~ 1970s	1970s ~ 1980s	1980s ~ 1990s	Mid 1990s ~ Present
Key References	Coombs and Richards (1993); Braun (1998); Drejer (1997); Gerybadze (1994); Gregory (1995); Bruce (1958); Sherman (1952; 1953) – R&D Drejer (1997) – Budgeting Drejer (1997); Drejer and Riis (1999); Khalil (2000) – Technology Forecasting techniques	Chiaromonte (2004); Sundbo (2001); Ettlie (2000); Braun (1998); Drejer (1997); Mansfield (1989); Utterback and Abernathy (1975); Abernathy and Clark (1985); Henderson and Clark (1990); Betz (1994)- Innovation Management Drejer (1997); Pearson, et al., (1996) – Delphi forecasting, Project Management and Evaluation Yu (2006); Whitney (2007) - Theory of Inventive Problem Solving (TRIZ) Whitney (2007) – Market research Brent (1996) – Cost Benefit Analysis	Dussauge, et al., (1994); Chiaromonte (2004); Assimakopoulos (2007); Drejer (1997); Braun (1998) – Technology Planning Drejer (1997) – Scenario Forecasting, Technology Analysis and Business Planning Wilyard and McClees (1987); Dissel, Farrukh, Probert and Hunt (2006); Phaal, Farrukh, & Probert, (2004) - Technology Roadmapping Yu (2006) - Multi-criteria Decision Making and Lateral thinking	Burgelman, et al., (2009); Chanaron and Grange (2007); Chiaromonte (2004); Drejer (1997); Dussauge, et al., (1994); Betz (1994); - Strategic MOT Garcia Arreola (1996) - Technology Audit Model (TAM) Majchrzak (1996) - Model Learning Workplace, GRIPS and Technology Organisation and People (HITOP) Dissel, Farrukh, Probert and Hunt (2006) - Discounted Cash Flow, Real Option and Decision trees	Chiaromonte (2004); Sundbo (2001); Chanaron and Grange (2007); Assimakopoulos (2007); Burgelman, et al., (2009) - Strategic MOT and Innovation Salina and Salina (2007); Whitney (2007); Paramanathan, Farrukh, Phaal and Probert (2004); Dussauge, et al., (1994) - Technology Assessment/Audit and Inventorying Technological Asset
Focus	Product	Commercialisation	Planning	Integration	Innovation

Principles: **Principle 1** Technology Development	Technology S-curve as the starting point Managing resources to create new technology to develop new products	Invention as the starting point for Innovation Management Managing resources to create new commercial opportunities through technology advancement	Technology planning as a reaction to an environment no longer perceived as simple and stable End to end planning approach to R&D, innovation and commercialisation of stand-alone technology. Each technology is treated as a stand alone strand Treating the technological development process and procedure as a project	Technology is viewed as the starting point for Strategic Management of Technology (SMOT) Integrated approach to Technology Management integrating various strands of technology with the business life cycle Involvement of strategic management in technology management which increases the chance of technology being produced to fulfil the company's overall aims and objectives	Innovation is viewed as the starting point for Strategic Management of Technology and Innovation Capturing the innovation, not only on the technology itself, but also on the strategies, methodologies, techniques, and plans of actions
Principle 2 **Technology Improvement** Process of Improvement Result of Improvement	To improve asset / infrastructure Stable, simple and expanding	To improve innovation, and find more effective solutions for problems encountered Changing but predictable	To improve core competencies and manage the technological project within a confined manageable realm Changing and discontinuous	To improve intellectual property in order to gain a competitive advantage Changing, discontinuous, unpredictable, with new dimensions	To enhance intellectual property and maximise the outcome even though there is scarcity and limitations on some resources High level of competition which potentially causes technological failure not only after being placed in a market place, but also in the embryonic stage of development

Principle 3 Technology Leadership	Provide funds for R&D	Emphasis on innovation process includes all functions from R&D to manufacturing and marketing	Emphasis on technology planning in which the project/company aims are the ultimate rules of thumb	Emphasising the importance of other resources (such as human resources) and organisational measures to be integrated with technological development	Attaining company's ultimate objectives in the face of macro (PESTLE) challenges and uncertainties, both internal and external
Principle 4 Technology Partnerships / Supplier Participation	Supplying materials and services only The relationship is simple, between customers, suppliers and businesses	Suppliers provide added value for materials and services Some participation at the operational level, suppliers provide specific information, advice and guidance demanded by the customers	Being participative in accomplishing what has been planned and requested by the customers Playing a role as a team in operations, but in a rigid and specific way. Suppliers need to comply with the planning tasks within operations, (time, quality, quantity) in order to establish a customer/supplier relationship between business and technological activities	Strategic and operational partnership. The relationship is intimate for long-term cooperation The suppliers fully participate in the operations, and are responsible for the success and failure of the operations	Suppliers have been partners in operations; they hold higher responsibilities and significant roles in the success or failure of the operations. Suppliers become the experts in providing the latest information and guidance, sharing, and building mutual sustainable relationships between themselves and their customers. Symbiosis relationship established
Principle 5 Technology Pioneering	Building on / create new technology	Commercialisation of technology, aimed at the applications of better ways of doing things, and more effective actions	Manageable elements in producing the technology (masterpieces)	Technology at the forefront for gaining a competitive advantage	Collaborative technology, breakthrough the uncertainties and sustaining a competitive advantage
Principle 6 Technological Integration	Technology is fragmented	More explicit link to business strategy rather than technology itself	Integration at the research and development (R & D) and marketing interface	Integrating technology and business strategies	Integrated strategic technology management with innovations It is the focal point in the refinement of strategy and technology itself

					Technology used to enhance competitiveness
Principle 7 Technological Value	Performance of the final product	Technology as adding value to economics where the cost is the major concern	Time to market the technology is the utmost concern	Link technology to the market to realise value Marketplace creates the balance of acceptance of new technology (i.e. the market decides on the new technology)	Marketplace creates the balance of acceptance of new technology (market that decides the new technology) or technology would potentially create the market demand
Principle 8 Technology Standard	Standard in the technology of the product	Standard in the technology of the process	Industrial Standard	Public Standard (standard in technology available to the public)	Brand Standard (standard become the brand name)
Systems	Curiosity driven Research and Development (R&D) project	Commercially driven Research and Development (R&D) project	Technology Life Cycle	Integrated technology life cycle within the business life cycle	Systems integration with business model (i.e. networking model)
Tools & Techniques	Budgeting Technology forecasting techniques	Project Management and Evaluation Market Research Delphi Forecasting Theory of Inventive Problem Solving (TRIZ) Cost Benefit Analysis	Scenario forecasting Technology analysis and Business Planning Technology Road Mapping Multi-criteria decision making Lateral thinking	Technology Audit Model (TAM) Discounted Cash Flow Real Option Decision trees Model Learning Workplace GRIPS Technology Organisation and People (HITOP)	Technology Assessment/Audit Inventorying Technological Asset

Table 4.2 is an author's opinion, which is informed by the literature on how various focus, principles, systems, tools and techniques have developed and evolved over the eras (categorised into the boxes). However, the reality is not as clear cut as it is. Therefore, they should not be taken as definitive. What is more important is that the reader sees the big picture and gains an understanding of how 'focus, principles, systems, tools and techniques' of this discipline have developed, rather than worrying about the allocations. As different authors/researchers may look from different perspective and may likely placing the context into different eras/context, the table is indicative.

4.5 Conclusions

This chapter has discussed the patterns and trends on how principles, systems, and tools and techniques have developed and evolved through the eras in quality and technology management. It appears that what drives the evolution of systems, tools and techniques of Quality Management (QM) and Technology Management (TM) is the principles (i.e. principles as the driving force). In the next chapter, the research discusses general business trends before predicting where these principles of QM and TM will be in the future. Additionally, the researcher will analyse, synthesise, predict what could be the future of QM and TM, and predict the commonalities and relationships between these two fields. Further, the researcher is also going to look at what the business trends suggest about the future and how that these would affect QM and TM fields.

CHAPTER 5

Analysis and Synthesis of Literature

5.1 Introduction

The purpose of this chapter is to analyse and synthesise the quality and technology management fields in order to meet the aim of identifying potential future developments in these two fields. As mentioned in **Chapter 4**, the principles are the driving force behind the evolution of systems, tools and techniques in these two fields. Therefore, as the researcher is looking at how these principles, systems, tools and techniques might evolve, this chapter will begin with a discussion of the principles, then the implications of this on the evolution of the systems, and tools and techniques.

This idea is in line with Hamel (2007, p. 147) where in his book 'The Future of Management' he insists that embracing new principles is essential for future management. This also aligns with Malone (2004) who claims that the practice of future work (i.e. networked organisations) must be built from principles. As a result, this chapter is focused on the principles of QM and TM looking into the future and identifying the common ground between these two fields.

Further, the purpose of this chapter is to examine the importance of the present and predicted future business and global trends. In order to achieve this, the researcher focuses on two issues:-

i. An overview of how today's global issues and business trends will continue into the future.
ii. A discussion of how the principles of quality and technology management will be affected by these trends.

The illustration of quality management, technology management and business trends merger of this research is shown in **Figure 5.1** as follows.

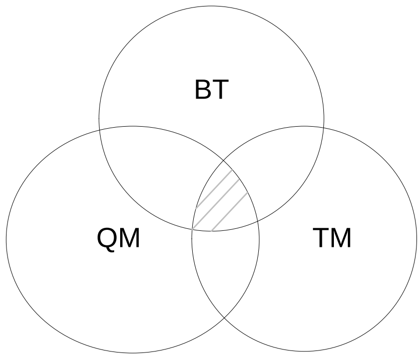

Figure 5.1: Quality management, Technology Management and Business Trend merger

5.2 Business Trends Overview: From Past to Present

The objective of this section is to understand the overview of business trends, so that the researcher can predict the next era in the evolution of quality management and technology management. The researcher has chosen to start this overview of business trends from the start of the industrial age because most of the modern management methods have evolved from practices adopted since the British Industrial Revolution (Fel, Gille, Parent, & Russo, 1986). Bititci, Garengo, Dorfler and Nudurupati (2008) further update this by suggesting that there are four eras describing the evolution of business trends from the industrial revolution to the present. These eras are:

(1) *Just-in-Case Era*. During this period most of the wealth was produced by manufacturing companies, which were producing a limited range of products and primarily focused on efficiency. The companies made stock, just in case it was needed. The social and business changes were slow, incremental and predictable and thus companies could plan for the future.

(2) *Lean Era.* This was a period of consolidation and rationalisation by focusing on strategic priorities and removal of anything that did not add value towards the achievement of the strategic objectives. The responsibility of managers was shifted to delivering these objectives, so the managerial work itself was becoming more complex. During this period, more flexible and more cost effective systems developed. The production processes became more complex, as everything was tight and lean.

(3) *Agile Era*. During this period, organisations continued to focus on value-adding activities and started to minimise the distraction of other peripheral activities. These encompass competencies and capabilities, which took the

lean principles to another level by organisations focusing on their core competencies and outsourcing their non-core activities.

(4) *Networking Era*. This period can be seen as the focus shifting from competition to collaboration, where a new type of work emerges that is different from both the manual-work and knowledge-work. The organising principle is fast moving towards netocracy, with flexible, flat and ever emerging trans-organisational networks where small organisations, and even individuals, are forming and reforming global collaborative networks to deliver innovative value propositions to global markets and customers.

All these reflect that, the last three eras; Lean era, Agile era and Networking era are not mutually exclusive. Hence, there are building each other (i.e. compounding effect). For example, the concept of agile includes Lean Enterprise and Networking concept include agility (i.e. the need to change) and at the same time being lean. Means that this does not exclude the concept, but Just-in-Case is not including in anyone of those. So, this also reflects that the Lean era is the turning point.

As such, Bititci, et al., (2008) further propose elaborate on the business eras and key characteristics as presented in the **Table 5.1** below.

Table 5.1: Business eras and key characteristics

	Just-in-Case Era	Lean Era	Agile Era	Networking Era
Approximate Timings in Decades	Early 1900s to mid 1970s	Mid 1970s to late 1990s	Mid 1990s to late 2000s	Mid 2000s to unknown
Scope, Rate and scale of change	Organisation, Slow and incremental	Organisation Fast, predictable and incremental	Supply Chain Turbulent, discontinuous and radical	Network Disruptive and transformational
Products	Artefacts	Artefacts supported by services	Services supported by artefacts	Social and environmentally responsible services supported by artefacts
Dominant Means of Production	Infrastructure owned by the organisation	Infrastructure and IP owned by the organisation.	IP owned by the organisation. Personal knowledge owned by the knowledge-worker	Knowledge and network connections owned by the net-workers
Competitive Forces	Unclear mix of all factors dominated by costs	Focus and differentiation	Value propositions	Being unique in different ways
Performance focus	Efficiency	Effectiveness and waste minimisation	Competitiveness	Triple bottom line in the context of the network

Work	Manual work	Manual work supported by knowledge work	Knowledge work supported by manual work	Net-work supported by knowledge and manual work
Management Competencies	Planning and production	Scenario planning and change management	Learning and intuition. Rapid response to changes	Global autopoietic networking real-time response.
Scope of Management Responsibility	Business as usual. Operational planning and correctly carrying out the task	Delivering the strategic objectives	Conducting successful ad hoc projects; managing/leading temporary, trans-organisational teams	Managing/leadings networks, people in multiple networks and networks of networks
Organizing principle	Autocracy	Bureaucracy	Adhocracy	Netocracy
Organisational Power	Few powerful individuals	Organisational structure	Processes, process owners and process teams	Individuals/small groups in multiple networks
People	Labour-force seen as necessary evil	Human resources seen as assets	Teams assets and investment	Individuals and autopoietic teams as Innovators and Heuristics
Regulatory system	Contracts, laws and regulations	Contracts, laws, regulations and industry standards	Contracts, laws, regulations, industry standards and accepted best practices	Trust, relationships and network standards
Organisational Relationships	Inter-organisational and Adversarial	Inter-organisational and Cooperative	Inter / trans organisational and Collaborative	Trans organisational, Communities of practice
Market dominance	Producer	Cost-conscious customer	Value-conscious, loyal customer	Disloyal, picky, curious, Impulse-customer

Source: Adopted from Bititci, Garengo, Dofler and Nudurupati (2008)

In this **Table 5.1**, Bititci et al. (2008) pinpoint the development of business eras and key characteristics. The table is obviously an oversimplification of the reality. However, it is actually its purpose. It is impossible to capture the richness of real world, let alone a hundred years of evolution of the business world, and it is impossible to have everyone agreed about the details, as different experts will have different perspectives. The purpose and the usefulness of the table is that by means of simplification it provides clear and reasonably stable points of orientation onto which those who are exploring something else in the field can hold, not spending too much effort on understanding all the underlying complexities but rather focusing on their area of primary interest.

As a whole, looking at the big picture, there is a trend emerging from it, rather than worrying about the allocations. This reflects that the networking era is emerging; that is the number of people connecting to each other, open innovation, and increasing work and business being conducted in the net environment.

5.3 Future Context

It is becoming clear that distance is no longer an obstacle to the accession of information. The business environment becomes fuzzy with unclear interrelations and an overlap between the player and the roles. Clearly, the world is changing so fast with new trends emerging. As such, there are several literature studies which propose the future context (Hamel, 2007; Malone, 2004; Prahalad, 1998; Prahalad & Krishnan, 2008; Priestley & Samaddar, 2007; Salina & Salina, 2007). Malone (2004) claims that the progress of these trends can be tracked back by looking at the business pattern. He notes that the business pattern has shifted from small business (independent, e.g., family business) to corporate business hierarchies (centralised, e.g., merger) and more recently to *business networks* (decentralised, e.g., *networked organisation*) (Malone, 2004, pp. 28-31).

Consistent with this, Bititci, et al., (2008) suggest that "*today, everything is global and fast; there are short-life-cycle products and processes; global products and services; mobile, flexible and distributed facilities; all connected together with real-time ICT capabilities managing workflows between distributed facilities and people*. *Organisations of all shapes and sizes, industrial, service or public have to consider end-to-end processes that include development, supply-chain and end-of-life management"*. Further, Bititci, et al., (2008) based on the works of Hammer and Stanton (1999) and Mintzberg (1983, 1998) point out that "*today as the typical organisational form become more responsive, the organising principle is the process, the power consequently resides with the process owners and the structures became secondary. The time became too short to establish proper inter-organisational relationships every time, so besides the highly valued inter-organisational relations trans-organisational relations emerge; the nature of these relationships is dominantly cooperative. The main role of the managers is to manage/lead temporarily, often trans-organisational teams"*.

The renew of literature on future trends identified sixteen (16) drivers which were established as future context. From the analysis of literature, **Table 5.2** briefly describes the transition dynamics of future contexts, which reflects the predicted movement of future changes.

Table 5.2: Predicted changes in business and social environment

Dynamic Transition	**Descriptions**	**References**
Web 1.0 to Web 2.0	This transition is from a passive web based technology to a participative social networking web. Web 2.0 provides the platform for participation, collaboration and creativity allowing more people to share their ideas and in more ways.	Gray, Thompson, Clerehan and Hamilton (2008); Hendler and Golbeck (2008); Needleman (2007); Mason and Rennie (2007); Hamel (2007)
Ideas and actions originating from the network rather than internally	The transition is where the ideas and actions are not solely built up within the organisation but across the network as well.	Bard and Soderqvist (2002); Hamel (2007)
Central Regulation to Self Regulation	This transition is from a wide span of control to self managed, self controlled, self organised processes and decision making where the individual is given more freedom in performing his/her task.	Prahalad and Krishnan (2008); Bititci, et al., (2008)
Contract to Trust	This transition is from formal or legal procedures to relationships based on trust. Trust becomes the main driver for every player to contribute and share their thoughts for relational improvement.	Crosno, Nygaard and Dahlstrom (2007); Acaccia, Kopacsi, Kovacs, Michelini and Razzoli (2007); Hamel (2007); Jahansoozi (2006); Malone (2004)
Legal Regulation to Moral Regulation	The transition is where the relationship is no longer bound solely by procedures and regulation and where there is a greater emphasis on morality. People prefer to make morally correct choices and actions (i.e. doing the 'right thing').	Ulhoi (2004); Bititci, et al., (2008); Hamel (2007); Malone (2004)
Increasing Transparency	This transition is from closed to open intellectual properties. The concept of transparency is linked to openness and is described as a required condition for rebuilding trust and commitment in relationships. The higher the level of openness and sharing, the greater the transparency achieved.	Jahansoozi (2006); Ulhoi (2004); Bessire (2005); Acaccia, et al., (2007); Malone (2004); Prahalad and Krishnan (2008)
Proprietary to Open Source	This transition is from the principle of closed source based on a profit motive to the principle of open source based on a non profit motive. The transition line is where the rights	Hamel (2007); Krogh (2003); Muir (2005); Ulhoi (2004); von Hippel and von Krogh (2003)

	of ownership are waived and the public are allowed to share and given access.	
Copyright to Copyleft	This transition is from legal rights protection to the waiving of certain public rights. A particular example of Copyleft is the General Public Licence.	Ulhoi (2004); de Laat (2005)
Increasing Emphasis on Innovation	The transition line is on the emphasis of innovation in networking where innovation comes in the form of open source innovation as the result of across the network participation and collaboration.	Ulhoi (2004); Malone (2004); Boudreau and Lakhani (2009); Machado and Manaus (2007); Prahalad and Krishnan (2008)
Bureaucracy to Netocracy	This transition is from hierarchical, procedural and rigid structures to flat, loose and flexible structures. Netocracy in the context of social governing reflects the idea of moving from an industrial society where social values are money driven to a humanitarian society which is knowledge driven.	Bard and Soderqvist (2002); Malone (2004)
Clear Organisational Boundaries to Fuzzy Organisational Boundaries	This transition line is from formal and clear organisational boundaries to loose and fuzzy organisational boundaries. This will allow businesses to become more responsive and enhance their ability to change.	Bititci, et al., (2008); Malone (2004)
Increasing Emphasis on Community Opinion	The transition line reflects the idea of increasing the emphasis on community opinion with the objective of gaining peer recognition, reputation and community prestige.	Ulhoi (2004)
Increasing Emphasis on Continuous Learning	The transition line reflects the idea of increasing the emphasis on learning opportunities and enhancing knowledge literacy mainly through the network. The fastest way for learning is through conversation, blogs and web.	Ulhoi (2004)
Increasing Emphasis on Corporate Social and Environmental Responsibility	The transition line suggests that businesses go beyond money making via commercial activities and make a commitment to the well-being of the community. e.g. ISO 26000 (Social Responsibility).	Robins (2005); O'Connor and Meister (2008); Falck and Heblich (2007); Baron (2008); Husted and Allen (2007); Yoon, Giirhan-Canli and Schwarz (2006); Castka and Balzarova (2008)
Loyal Customers to Picky/Curious Customers	The transition line is where customers have become more educated especially the younger generation and so have become highly selective and curious in choosing products or services.	Chang, Hung and Ho (2007); Demoulina and Ziddab (2007); Bititci, et al., (2008)
Increasing Pace of Change	The transition line reflects the pull of ideas for improving and rectifying problems more quickly, as the result of breeding ideas and solutions mainly through the network.	Bititci, et al., (2008); Hamel (2007); Prahalad and Krishnan (2008)

In this chapter so far, the research has discussed what business and social trends will be in the future. From this point, the researcher synthesised the findings from the in-depth literature review of quality and technology management, and the quality and technology management principles developed over time (evolved through eras) to try to predict how they could develop into the future; the envisioning of the potential future for quality and technology management. In order to do that, the potential impacts of the 16 drivers are mapped onto the corresponding quality and technology management principles. From there, the researcher assessed how they may change in the future.

The detailed process of thought, which discusses the justification for the future transition of quality and technology management principles, can be found in the **Appendix A** and **Appendix B**. Therefore, the readers are encouraged to refer to **Appendix A** and **B** for detail or particularly questions of how the listed points opinion were derived, as the author has made it explicit in the appendices.

5.4 The future context of quality management

Based on the analysis and mapping, **Table 4.1** has been extended to include; (1) Contexts of future and (2) Future of quality management principles, as presented in **Table 5.3**. Each principle is then discussed in more detail in terms of future characteristics.

Table 5.3: Principles of Quality Management from Quality Inspection to QM 2.0

Dimension	Quality Inspection (QI)	Quality Control (QC)	Quality Assurance (QA)	Total Quality Control (TQC)	Total Quality Management (Business Excellence)	Contexts	QM 2.0
Principle 1 Continuous Quality Improvement	Sorting good from bad Corrective Action	Use of statistical tools to control process output Corrective Action	Systematic but fragmented improvement Preventive Action	Systematic managed continuous improvement Managed prevention and improvement	Systematic and habitual continuous improvement Habitual prevention and improvement	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	Network wide continuous improvement which is based on:- - Habitual - Self managed - Transparent - Open source - Participative - Collaborative - Trust - Originated across network - Moral regulation - Corporate Social and Environmental Responsibility
Principle 2 Conformance to Standard	Conformance to product standard	Conformance to product standard	Conformance to process standard in the operational system	Conformance to systematic improvement standard (Managed)	Conformance to systematic improvement standard (Habitual)	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Increasing Pace of Change	Conformance to network standard which is based on:- - Innovation - Self Regulation - Continuous Learning - Knowledge sharing - Community opinion - Corporate Social and Environmental Responsibility
Principle 3 Management Understanding	Specialisation of labour Quality subordinate to cost - 	Specialisation of labour Quality subordinate to cost Systematic documentation and review of product specifications and inspection procedures and responsibilities	Multi skilled labour - Systematic documentation and review of quality policies, procedures and responsibilities (e.g., Quality Management System)	Multi skilled and cross functional teams (Managed) - Managed systematic use of tools and techniques facilitating objective/structured management	Multi skilled cross functional teams (Habitual) - Habitual use of tools and techniques facilitating objective/structured management	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Increasing Pace of Change	- Self organising teams from across enterprise in which trust, openness and transparency becomes the managerial philosophy/approach - People operating as innovative problem solvers - Loosening the hierarchy with greater emphasis on harnessing democracy and coordinating activities

Principle 4 Customer Orientation	Customer is a necessary evil	Customer has no choice	Understanding customers requirements through capturing, documentation and review of customer requirements	Customer satisfaction by fulfilling and exceeding customers requirements	Customer delight in service dominant culture adding value to customers, business, life and etc.	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Increasing Transparency, Proprietary to Open Source, Increasing Emphasis on Innovation, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	- Customer is part of the network - Continuous customer engagement and reengagement in the form of collaboration, innovation and learning with the customer as an integral part of the network
Principle 5 Quality Leadership	Command	Command and control	Systems and control	Participatory	Coherent leadership with excellence mindset	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Increasing Transparency, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Corporate Social and Environmental Responsibility, Increasing Pace of Change	- Innovative leadership mindset - Complex system of leadership and coaching
Principle 6 Quality Involvement	No involvement	No involvement	Controlled involvement	Managed involvement	Habitual involvement at all level	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Legal Regulation to Moral Regulation, Proprietary to Open Source, Increasing Emphasis on Innovation, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Pace of Change	- Virtual involvement - More dynamic members sharing ideas, experience and knowledge
Principle 7 Quality Supplier Relationships	Adversarial arm's length (i.e. no relationship)	Adversarial arm's length (i.e. no relationship)	Controlled partner relationships	Managed partner relationships	Habitual involvement of partner in continuous improvement activities	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Contract to Trust, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Increasing Pace of Change	Supplier involvement in open source improvement activities throughout the network
Principle 8 Process Management	No recognition of the process	Fragmented	Integrated process control	Systematic process management	Processes are managed as an integrated system	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally,	- Processes extend beyond organisational boundaries - Extended processes are managed

						Central Regulation to Self Regulation, Contract to Trust, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	as an integrated system across network
Principle 9 System Management	No system thinking or understanding	Understanding isolated cause and effects in product quality Product	Understanding simple causes and effects in the process Discrete proven process	Understanding complex causality in the operational processes Operational processes	Understanding complex system causalities of business processes including operational, managerial, support and human factors Complex system causalities	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	Understanding complex causalities, including people, across the network extended processes

Principle 1: Continuous Quality Improvement

Based on the analysis, continuous quality improvement in the future will be network-based improvement where there will be more open innovation, participation and collaboration. Further, the continuous improvement will be self-organising/self organised, as people and knowledge will be shared freely amongst the network partners. This will result in the following outcomes:

- Improvement through ideas and innovation coming from the network not solely from internal organisation (e.g. through suggestion scheme and Gemba Kaizen) with continuous change.
- Continuous improvement will be done in the manner of 'participative and collaborative improvement' across the networks. Participative improvement in this context is a reflection of the members in a virtual organisation or practise group, who participate and communicate with each other via blogs and organisational web sites. Initially, problems, ideas, quality solutions etc are the issues that need to be solved across this network. The synergy of this network leads to collaborative improvements where particular ideas are put into action.
- More organisations will invite outsiders to comment on their suggested design improvements, so that members from the practice community can share with each other their comments, reviews, and feedbacks on this quality improvement (i.e. quality improvement through open innovation).
- Evidence of some actions taken place in the networks, as the result of communication (i.e. participation and collaboration). New methods of communication (e.g. blog, wiki and forum) can greatly lower the cost of exchanging information and of providing the people with information. It is easy, fast and cheap to experiment.
- Architectures that are open, flat, malleable and non-hierarchical, whereby everyone has a voice; the tools of creativity are widely distributed.
- Continuous learning opportunities will be the important driving force for quality improvement, where it simultaneously provide a process of development for contributors and improvement for participators. As everyone

learns and participate in quality improvement. Self-learning and self-satisfaction counts for more than credentials and titles.

- The improvement is persistent and resilient with more ways in doing things, as the options continuously evolve (i.e. increase pace of change).

Principle 2: Conformance to Standard

The next generation of the principle conformance to standard could be conformance to network standard/open standard, extended to control quality in the market. This will be based on self-organising/self-management/self-regulation, trust, morality and transparency with more knowledge sharing and community opinion taking place. This eventually will shape the future of conformance to standard as follows:

- In current Quality Management standards, the focus is on people's competencies. In the future, the focus will shift more on trust, morality (ethics) and transparency. So current quality standards may need to be refined to take into consideration the new elements of trust and transparency. For example, the Internet Engineering Task Force (IETF) is an open-technology community that develops standards for the Internet - the IETF community develops open technical standards. IETF processes are transparent and all resulting technology is freely available, where the IETF has no formal membership restrictions or voting rights, and any individual is free to propose new technical standards (Waguespack & Fleming, 2009). See also Internet Engineering Task Force (IETF) at http://www.ietf.org/.
- Other drivers will come into play such as self-regulation/self-management, where the user is both a contributor and participator. Ideally, this means that standards could be self-regulated (i.e. following the eBay business model and IETF model).
- The introduction of reputation systems and business network models (profile based) could be introduced to help people choose high quality providers, where specific quality standards would not be relevant.
- A new quality standard may need to be released for networking standards, in order to accommodate large-scale business and social interaction in the net (e.g. internet and intranet).

- The future quality standards could be tailored for networking standards, where there is a need to recognise the issues of leadership (i.e. managing coaching leadership), partnership, collaboration, continuous improvement, privacy and security concerns in the networks context.
- A new standard should also consider the evolution of corporate social and environmental responsibility. It is a possibility for this element in the ISO 26000 standard to be merged into the new networking standards as well.

Principle 3: Management Understanding

The principle of management understanding in the future could be based on loosening the hierarchy with greater emphasis on harnessing democracy and coordinating activities. This leads to cultivating people, self-organising, people-centered, peer-to-peer and transparency being the central agenda. This will result in the following outcomes:

- Future movement is supported by incremental transparency, from closed to open organisations with regards to intellectual property (i.e. open content).
- Openness will be the sticking point for companies as to how far the organisation is willing to share information and seek knowledge within and outwith the organisation.
- There is a move toward a flat organisation structure with transparency and controlled real time data access to all levels (Prahalad & Krishnan, 2008, p. 170).
- From rigid organisational charts to fluid operations models and project teams.
- Self-organising teams from across the enterprise in which trust, openness and transparency becomes the managerial philosophy/approach.
- People operating as innovative problem solvers.
- Future organisations will demand a quick decision in the dissemination of information. As a result of this, the new management structure will reflect the transition from bureaucracy to netocracy (i.e. flat, flexible and fuzzy boundaries).
- The only hierarchies are ‘natural hierarchy’. For example, Linux was written by a loosely coordinated hierarchy of thousands of volunteer programmers all

over the world (open content). An even looser hierarchy exists for Wikipedia creating an Encyclopedia (Malone, 2004, p. 43). Ideally, this helps the business become responsive and enhance its operational pace of change.

Principle 4: Customer Orientation

The principle of customer orientation in the future could be based on the customer as part of the network/business model with the need for customer interfaces, establishing trust and transparency. This will result in the following outcomes:

- Customer provides a wide variety of skills and motivation levels which promote dialogue with producers/manufacturer and among consumers. A simple interface is a prerequisite for this.
- Customers are increasingly a source of competence (Prahalad & Krishnan, 2008). An informed and active customer base is emerging. Customers are willing to engage and co-create their personalised experiences (Prahalad & Krishnan, 2008, p.235).
- Continuous customer engagement and reengagement in the form of collaboration, innovation and learning with the customer as an integral part of the network.
- The social movement puts forward the view that customers should participate actively in the product and services development and share their thoughts and reviews of the products. This two-way communication is believed to increase transparency in the relationship between the producers, suppliers and even customers. In addition, this movement provides a platform for promoting new ideas of innovation and fostering new knowledge.

Principle 5: Quality Leadership

The principle of quality leadership in the future may be based on ‘swarming’ – the coaching leadership in network (Malone, 2004) and innovative leadership mindsets in the complex system of leadership and coaching. The leader will be more empowered, democratic and decisions are peer-based. This will result in the following outcomes:

- Future leadership is anticipated to be closely related to issues of corporate social and environmental responsibility. This matches with the increased focus on compliance with environmental and corporate social standard (e.g. ISO 14000 and ISO 26000).
- The leadership will come from across the network as part of the coaching process, as more people seek faster information and solutions through the network, leading to the emerging coaching leadership. Shifting from power based on position to power based on respect, trust, and expertise.
- Ideas compete on an equal footing. Quality leadership will be more transparent with a high degree of openness and sharing, where the information and decision-making processes will be on view to the public.
- From command and control to coordinate and cultivate. Cultivate means taking advantage of people’s true intelligence and creativity, which are the most critical capabilities of successful businesses.
- From narrow, constraining job descriptions to a dynamic, tradable portfolio of operational, project, and leadership roles that tap into people's full potential.
- Power is granted from below where the authority is fluid and contingent or value-added and just about everything is decentralised.
- From reactive top-down assignments to proactive bottom-up initiatives by self-organising teams.

Principle 6: Quality Involvement

The future principle of quality involvement would be based on virtual involvement with participation, people-centered, employee engagement, collaborative team and self-control essentially being the next agenda. This will result in the following outcomes:

- The involvement comes both internally and beyond the boundaries of organisation. More dynamic members sharing ideas, experience and knowledge.
- This leads to involvement in the context of open source innovation, which is more holistic, involving employees, suppliers and customers.

- This moves the idea from employees as cogs in a machine, offshored to the lowest bidder, to creative, empowered team members.
- Employees shift from a confined/narrow job description to providing services/roles for an evolving portfolio of initiatives, which can be more proactive, instead of simply reactive to the superior.
- This shift will increase voluntary commitments (as opposed to forced assignments) and encourage more efficient group time utilisation via collaborative spaces.
- The embracing of the values generates self-guidance, self-policing, and peer responsibility for keeping one another aligned with the core set of principles, reducing the need for rules and thus helping people feel autonomous. Rather than feeling forced into conformity, employees feel that they are wilful actors making their own choices based on principles they can support.

Principle 7: Quality Supplier Relationship

In the future, the principle of quality supplier relationship would be based on collaboration in supplier relationship/collaborative networks, where suppliers and customers integrate their business model while competing and complementing each other. In relation, there will be more need to establish trust, transparency and open source innovation. This will result with the following outcomes:

- The relationship is shifting from supplier relationships to supplier involvement (supplier partnering) in open source improvement activities throughout the network.
- Supplier/partnerships are competing and complementary (coopetition) with producers and each other at the same time.
- Open source innovation provides the platform for suppliers to be more actively involved in the company's activities.
- Interconnection is accomplished easily with other systems from within the firm and vendors. This may lead to better supplier relationships, as supplier involvement becomes the norm and the two-way relationship happens regularly and is not just a one-off meeting. Crucially miscommunication and misinterpretation can be reduced.

- Future supplier relations will involve facilitating collaboration across the firm and its partners and thus identifying new opportunities for process innovation and customer value (Prahalad & Krishnan, 2008, p. 183).

Principle 8: Process Management

The future principle of process management would be based on processes extending beyond organisational boundaries where extended processes are managed as an integrated system across the networks. This will result in the following outcomes:

- Managing external (outside) processes are the major challenge, as the processes extend beyond organisational boundaries where extended processes are managed as an integrated system across the networks.
- There will be more self-regulation, where each quality activity is a process that can be self-organised by the quality members. Inevitably, every person can take part in the process improvement, meaning it obtains solutions from the greater pool of sources, which may also include the expert across the network. For example, DuPont's R&D staff who are trained in Six Sigma help to improve processes by removing cost from supply chains, attacking slow-moving inventory, and streamlining innovation processes across their operation (Chowdhry, 2010).
- An increased success in implementation of new processes and a much-reduced rate of failure, as more people can gel together. This provides a better learning opportunity, and much improved information being shared to enhance knowledge. Eventually, every new idea that improves the process may contribute to knowledge literacy. Significantly, this may help to speed up the pace of change and the response to problems and provide future solutions for managing quality processes.

Principle 9: System Management

The future principle of system management would be based on complex causalities, including people and across network extended processes. This will result with the following outcomes:

- Processes are managed as an integrated system, so the principle of process management is the foundation for future changes of system management.
- System management as a whole becomes much more complex as the interrelated processes (e.g. internal and external processes) are embedded in the system, which extend beyond the internal boundaries of the organisation.
- System management in the future may be shifting to better understanding complex causalities, including people, across the network extended processes.

5.5 The future context of technology management

Literature in technology management says very little about placing technology management principles into the future context. Even the principles of technology management are rarely discussed in the literature, as most is focused on the direction of incorporating technological issues into business thinking, decisions and processes (Gregory, 1995; Phaal, et al., 2004; Phaal, et al., 1998). Therefore, it is believed that the proposed concepts and pertinent ideas in this section are expected to be of high value for the researchers and practitioners in exploring the future context of technology management. This section also reveals the principles in technology management as of today and attempts to answer what impact these principles might have in the future (on technology management) and how future development (future context) might affect current technology management principles.

Based on the analysis and mapping (as previously mentioned in **Section 5.3**), **Table 4.2** has been extended to include; (1) Contexts of future and (2) Future of technology management principles, as presented in **Table 5.4**. Each principle is then discussed in more detail in terms of future characteristics.

Table 5.4: Principles of Technology Management from R&D to TM 2.0

Technology Management (TM) Era	Research & Development (R&D)	Innovation Management (IM)	Technology Planning (TP)	Strategic Management of Technology (SMOT)	Strategic Management of Technology & Innovation	Contexts	TM 2.0
Approximate Timings	1950s~1960s	1960s~1970s	1970s~1980s	1980s~1990s	Mid 1990s ~ Present	Future	Future
Principle1 Technology Development	Technology S-curve as the starting point Managing resources to create new technology to develop new products	Invention as the starting point for Innovation Management Managing resources to create new commercial opportunities through technology advancement	Technology planning as a reaction to an environment, no longer perceived as simple and stable End to end planning approach to R&D, innovation and commercialisation of a stand-alone technology. Each technology is treated as a stand alone strand Treating the technological development process and procedure as a project	Technology is viewed as the starting point for Strategic Management of Technology (SMOT) Integrated approach to Technology Management integrating various strands of technology with the business life cycle Involvement of strategic management in technology management which increases the chance of technology being produced to fulfil the company's overall aims and objectives	Strategic Management of Technology and Innovation coming together Capturing the innovation not only on the technology itself, but also on the strategies, methodology, techniques, and plans of actions	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	Creating new opportunities of development and strategies in harnessing millions of people over the network to co-create products through peer production, engaging community of practices and open source movement
Principle 2 **Technology Improvement**						Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	Networking wide technology improvement which is based on:- - Web 2.0 - Self managed - Trust - Moral regulation - Transparent - Open source and copyleft - Participative - Collaborative - Innovation - Originated across network - Community Opinion - Knowledge Sharing - Corporate Social and Environmental Responsibility
Process of Improvement	To improve asset / infrastructure	To improve innovation, finding more effective solutions for problems encountered	To improve core competencies and manage the technological project within a confined manageable realm	To improve intellectual property to gain competitive advantage	To enhance intellectual property and maximise the outcome even though there is scarcity and limitations on some resources		
Result of Improvement	Stable, simple and expanding	Changing but predictable	Changing and discontinuous	Changing, discontinuous, unpredictable, with new dimensions	High level of competition which potentially causes technological failure not only after being placed in a market place, but also in the embryonic stage of development		

Principle 3 Technology Leadership	Provide funds for R&D	Emphasis on innovation process includes all the function from R&D to manufacturing and marketing	Emphasis on technology planning in which the project/company aims are the ultimate rules of thumb	Emphasising the importance of other resources (such as human resources) and organisational measures to be integrated with technological development	Attaining company's ultimate objectives in the face of marco (PESTLE) challenges and high uncertainties internal and externally	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	- Handling technology development , management, scalability and openness issues - How to design, build, launch, market, support and maintain products and services, and to be effective in working within and directing communities of employees, users and partners in accomplishing large scale of outcomes
Principle 4 Technology Partnerships / Supplier Participation	Supplying materials and services only The relationship is simple between customer , suppliers and the business	Suppliers provide added value for materials and services Some participation at the operational level, suppliers provide specific information, advice and guidance demanded by the customers	Being participative in accomplishing what has been planned and requested by the customers Playing a role as a team in operations, but in a rigid and specific way. Suppliers need to comply with the planning tasks within operations, (time, quality, quantity) in order to establish a customer/supplier relationship between business and technology activities	Strategic and operational partnership. The relationship is intimate for long-term cooperation The suppliers fully participate in the operations, responsible for the success and failure of the operations	Suppliers have been a partner for operations, who hold higher responsibilities and significant roles in the success or failure of the operations. Suppliers become the experts in providing the latest information and guidance, sharing, and building mutual sustainable relationships between themselves and their customers. Symbiosis relationship established	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Contract to Trust, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Increasing Pace of Change	- Suppliers and partnerships having a much closer relationship because of social integration and tightly integrated online supply chains - Relationships built upon trust, openness and transparency
Principle 5 Technology Pioneering	Building on / create new technology	Commercialisation of technology, aimed at the applications of better ways of doing things, more effective actions	Manageable elements in producing the technology (masterpieces)	Technology at the forefront for gaining competitive advantage	Collaborative technology, breakthrough the uncertainties and sustaining competitive advantage	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous	Collaborative network technology with architectures of participation on building collective intelligence

						Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Loyal Customer to Picky/Curious Customers, Increasing Pace of Change	
Principle 6 Technological Integration	Technology is fragmented	More explicit link to business strategy rather technology itself	Technology rigidly integrated within business or corporate wide managerial operations	Integrated strategy, technology and business	Integrated strategic management of technology with innovations It is the focal point in refinement of strategy and technology itself Technology used to enhance competitiveness	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Contract to Trust, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Clear Organisation to Fuzzy Organisation Boundaries, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Increasing Pace of Change	- Technology becoming the driving force in leading/endeavour innovation and integrating business new mode for communicating, collaborating, socialising and working together - Systems integration with business model amongst the network partners
Principle 7 Technological Value	Performance of the final product	Technology as adding value to economics where the cost is the major concern	Time to market for the technology is the utmost concern	Link technology to the market to realise value Marketplace creates the balance of acceptance of new technology (market that decides the new technology)	Marketplace creates the balance of acceptance of new technology (market that decides the new technology) or technology would potentially create the market demand	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Legal Regulation to Moral Regulation, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Increasing Emphasis on Community Opinion, Loyal Customer to Picky/Curious Customers	Technology as the platform which creates the opportunities to be expanded to host networking (e.g., corporate intranet and open social network) type functionality and collaboration tools
Principle 8 Technology Standards	Standard in technology of product	Standard in technology of process	Industrial Standard	Public Standard (standard in technology open to the public)	Brand Standard (standard become the brand name)	Web 1.0 to Web 2.0, Ideas and Actions Originating from the Network rather than Internally, Central Regulation to Self Regulation, Contract to Trust, Increasing Transparency, Proprietary to Open Source, Copyright to Copyleft, Increasing Emphasis on Innovation, Bureaucracy to Netocracy, Increasing Emphasis on Community Opinion, Increasing Emphasis on Continuous Learning, Increasing Emphasis on Corporate Social and Environmental Responsibility, Increasing Pace of Change	Open networking standards

Principle 1: Technology Development

In the future, technology development could be based on network orientation where Web 2.0 (the architecture platform for social networks) would be the pillar for technology development in providing a platform for participation, collaboration and creativity across the network (i.e. collaboration in networks/collaborative networks).

The development of new technology is not solely about internal R&D, but it also may come from third party development. Further, the technology development will put greater emphasis on sharing people and knowledge throughout the networks. This will result in the following outcomes:

- Creating new opportunities for development and strategies in harnessing millions of people over the network to co-create products through peer production, engaging communities of practice and the open source movement. This leads to development that comes from the synergy process via collaboration.
- Future technology development will closely link with collaboration and partnering across the wide network.
- The development of new technology is not solely about internal R&D, but it may come from outwith the organisations – 'globalised R&D'. This means that the ideas and actions originate across the network rather than just internally.
- There will be more third parties contributing to the development of new technologies.
- This will allow organisation resources flow more easily towards opportunities, as well as to address problems at an early stage. To a certain extent, this will result in cost saving and reduce development failure.
- The development of new technology will be more customised and tailored for the customer, where customer interaction and feedback is at the forefront.

Principle 2: Technology improvement

The principle of technology improvement in the future will be based on network-based/networking wide technology improvement. For instance, the improvement in terms of ideas and innovation come from the networks and not solely from inside the organisation (i.e. innovation as the heart of technology). As a result, managing external innovation will be the key issue with the tools of creativity widely distributed. As such, there will be more focus on self-management, establishing trust, transparency, open innovation (e.g. external innovation) and also participation and collaboration, as well as knowledge sharing and community opinion across the network. All these will result in the following outcomes:

- The improvement is persistence and resilient with more ways of doing things, as the options continuously evolve (i.e. through the participation and collaboration amongst the communities of practice).
- Technology improvement via external innovation, with multiple parallel paths to solve an innovation problem. In both markets and communities, external innovators will explore innovation landscapes that are often unknown and unexpected by the organisation. A high-performing solution often comes by this type of exploration (Boudreau & Lakhani, 2009).
- External innovation also appears to be more cost-effective, because the cost of failure is typically not borne by the host organisation. If an external innovator fails in its attempt to solve an innovation problem, then it alone bears the costs (and benefits of learning) from that attempt (Boudreau & Lakhani, 2009).
- External innovation appears to achieve fast solutions that arrive quite quickly and can often exceed the capacity of the seeker (Boudreau & Lakhani, 2009).

Principle 3: Technology Leadership

Technology leadership in the future is proposed to be about harnessing the technology, providing business value, managing the wide resources, and also based on swarming, empowerment and democracy with the complex system of the leadership, coaching and innovative leadership mindset being the central agenda. All these will result in the following outcomes:

- Harnessing the technology, where the leadership challenge needs to get the right technology to work towards providing business value (Hoving, 2007).

- Leadership in handling technology development, where management, scalability and openness are the issues. To a certain extent the decisions of technology direction is about how to design, build, launch, market, support and maintain products and services, and to be effective in working within and directing communities of employees, users and partners in accomplishing large scale outcomes.
- The ideas and actions concerning leadership in technology areas not only come from inside the organisation but also across the networks. Community leadership roles may be granted based on how active an individual is within the community as well as the quality and nature of his or her contributions.
- 'A swarm of bees and a school of fish leadership' are the metaphors that can describe coaching leadership in networks (Malone, 2004). As more people seek faster information and solutions through networks, then this leads to the emergence of coaching leadership.
- The leader of the network - the emergence of a communities leader – who is referred to by others without having the trappings of power. This means that this movement is moving to a situation where there is no real leader. Every one can participate and collaborate with each other and the position of leader can be rotated amongst them. This could truly happen if all the members have more or less the same capabilities in the performance of their work.

Principle 4: Technology Partnerships / Supplier Participation

In the future, technology partnerships/supplier participation would be based on collaboration in supplier relationship with greater emphasis on suppliers partnering into the business models. Further, this relationship will be more complex with competing and complementary activities happening at the same time. The establishment of trust, transparency and open source innovation will also occur. This will result in the following outcomes:

- Suppliers and partnerships having a much closer relationship because of social integration and tightly integrated online supply chains.

- Relationships built upon trust, openness and transparency (openness in information). This provides the platform for suppliers to communicate, review and evaluate their partnerships.
- The partners working closely with greater emphasis on knowledge and people sharing in building collective intelligent amongst themselves.
- Communication, interchanging ideas and solution take place amongst the suppliers and partnerships as the result of open source innovation movement and eventually help more rapid decision making and avoid misinterpretation.
- There will be more third parties; individuals and organisations, participating and collaborating in each other's business models.

Principle 5: Technology Pioneering

In the future, pioneering technology will not only be about being at the forefront - or acting as the front-runner in technological development - but will include a greater emphasis on establishing a more collaborative network of technology, with architectures of participation built on collective intelligence. This will result in the following outcomes:

- Technology pioneering via network collaboration, where the breakthrough of new technology to the market results from strategic collaboration in networks.
- In the future, pioneering technology is not all about being the sole champion of R&D or being the technological leader in the market, which takes much time and is very costly. What matters now is the ability to produce breakthrough technology to the market quicker and reliably by working closely with partners that have superior competencies.
- There will be increased productivity and efficiency as the result of quick responses through collaborative network technology, with architectures of participation built on collective intelligence. In addition, the shift requires the organisation to deal with multiple resources and the richness of information, with the key concern to disseminate and interpret them to obtain optimum results.
- Pioneering technology using 'cloud technology' – the internet server, where there is likely to be more big name players involved in cloud technology,

since it enables firms to offer connectivity to their products to a large customer base (shared resources and information). For example, Sony Corporation using Google Inc. Android platform – the cloud, to release their on line Blu-ray television in the internet in order to reach more customers across the world (Anonymous, 2010c).

- The shifts will bring more companies, especially in music, movies and gaming industries, into cloud technology with other industries following.

Principle 6: Technological Integration

In the future, technological integration would be based on internal and external systems integration with business models (i.e. networking model) through 'inter-enterprise applications', made possible by the advancement of Web Services and ERP (Hoving, 2007). For example, ERP has made cross-functional systems a necessity with the corresponding need to integrate common processes and technologies across the departments and, to a certain extent, across company borders as well. All of these will result in the following outcomes:

- Technology becoming the driving force in leading innovation and integrating new modes for communicating, collaborating, socialising and working together in the business.
- Develop the capacity to rapidly integrate new technologies and legacy assets via networks – Information Communication Telecommunication (ICT) platform (Prahalad & Krishnan, 2008, p. 126) and as the systems that can be integrated for independent enterprise (Wei, Tan, & Feng, 2009).
- Lead to globally integrated and locally responsive systems (Prahalad & Krishnan, 2008, p. 125).
- This shift results in the ability to use technology to integrate companies and ensure that all parties can properly react to supply chain disruptions, and implement a strategy to overcome problems and expand improvements. Leveraging integrated technologies, data is collected faster, allowing for a proactive analysis of the data to ensure more efficient and streamlined operations (Rabren, 2010).

Principle 7: Technological Value

In the future, technological value would be delivered on the basis of technology as an ICT platform that provides engagement with customers. There will be more value placed on collaboration networks for innovation as well as providing access to free resources to follow more opportunities. This will result in the following outcomes:

- Technology as the platform that creates the opportunities to be expanded to host networking type functionality and collaboration tools.
- The realisation of technological value not only through technology-to-market linking (wherein the technology embodied in a product to be meaningfully employed and can create benefits for its users (Gruber, MacMillan, & Thompson, 2008), but also provides the capacity to engage customers in a wide variety of activities, such as product development, pricing, and logistics (Prahalad & Krishnan, 2008).
- This co-creation nature of engagement can enable firms to learn about customers as a part of technological value creation process (Prahalad & Krishnan, 2008, p. 157).
- The shift also provides the value for technology in terms of speed (fast action and quick response) and access to people across the networks with interesting ideas and knowledge. Indeed, this creates wider coverage and unique improvement and development of technological value as a whole.

Principle 8: Technology Standards

The principle of technology standards (standards in technology) in the future could be based on open standards, where open technologies become the open networking standards. For instance, there will be more open linkages for business components. This will result in the following outcomes:

- ICT architecture allows the firm to continuously integrate new business processes and emerging technology standards with existing legacy systems and processes (Prahalad & Krishnan, 2008, p. 124).
- Business components have *open linkages* in which they connect with other components or external systems through standard and open interface such as

XML and can be improved by Web services (Prahalad & Krishnan, 2008, p. 132).

- Intellectual property (i.e. industrial standard) becoming community property (public standard), as a new generation of users and consumers of intellectual property produced by new technologies bring totally different assumptions and attitudes to bear on its ownership. As brands become less the property of an organisation and more the banner of a movement, ownership will become even looser.
- In the future, open technologies become the open networking standards. For example, Linux and Apache provide the most popular examples of open technologies and their underlying communities, where members donate time, knowledge, and collaborative effort to develop technology that is placed in the public domain (Waguespack & Fleming, 2009).
- To a certain extent, this shifts to the development of open technical standards, where an individual is free to propose new technical standards. For example, Internet Engineering Task Force (IETF) community develop the internet standards (Waguespack & Fleming, 2009).

5.6 Conclusions

In conclusion, it is clear that the future would be based on netocracy, network, open source and innovation. The impact that this future context may have on quality and technology management principles have been discussed. As mentioned in **Chapter 1**, quality and technology management are not mutually exclusive and there are some complementary aspects between these two fields. Having done the analyses and syntheses of quality and technology management principles in the previous section, the analysis of these projections allows the researcher to meet the aim of identifying potential areas of synergies, convergences and overlaps in future developments of quality and technology fields, and what is striking now is that there are potential convergences and synergies between these two fields.

It is becoming clear that in the principle of continuous improvement of both quality continuous improvement and technology improvement seem to have some commonalities in which, in the future these two principles may commonly be done network wide, engaging more people for improvement across the network. This principle informs that the future characteristics may consist of self-management, trust, transparent, open source, participative, collaborative, originating across network, and corporate social and environmental responsibility would be the driving factors in supporting the improvement.

Future principle of standards in the quality and technology management also shares some commonalities, as both principles are moving towards network standard with a greater emphasis on the open standards (i.e. open technical standards and open technologies standards). The driving force behind this principle will be based on web 2.0, self-regulation, trust, transparency, innovation, community opinion, continuous learning and increasing emphasis on corporate social and environmental responsibility.

As such, leadership is another area where it is becoming clear that the leadership in the future for both quality and technology management principle may share some commonalities as the leadership would also come from network. This principle suggests that the future characteristics that driving this principle to become complex system of leadership and coaching with swarming and innovative leadership mindset.

The other areas that seem converging for quality and technology management could be supplier relationships/partnerships. This can happen as this principle moving to a situation where suppliers and partnerships having a much closer relationship because of social integration and having tightly integrated online supply chains with the relationships built upon trust, openness and transparency amongst the parties.

Overall, four areas of synergies that strongly emerged from this analysis are; continuous improvement, standards, leadership and partnerships/supplier relationships, as all of these mentioned principles are moving towards network based operation. This eventually leads to the point where quality and technology management may converge and brings the synergies and complementarities of these two fields together. Furthermore, the analyses also revealed that networking is emerging as a future business model that may have a significant impact on the future of these two fields.

This prediction is consistent with a stream of literature that foresees the future of organisations lying in networking (Hamel, 2007; Malone, 2004; Salina & Salina, 2007). This chapter concludes that the four potential areas, i.e., continuous improvement, standards, leadership and partnerships/supplier relationships merit further study in the network context through case studies. Therefore, in order to study these phenomena and how they emerge in the future context, **the researcher will identify an organisation that is already aligned with future characteristics.** The justification of this approach is further discussed in **Section 6.4.2** in **Chapter 6**.

CHAPTER 6

Methodological framing of the research

6.1 Introduction

This chapter highlights the philosophical framework, including research paradigm and research strategies, as well as the research design and methods of research. In order for the researcher to make appropriate choices of methodological approach, Beech's framework (Beech, 2005) is followed to identify the research paradigm and the most appropriate strategy and methods for this research, as illustrated in **Figure 6.1** below.

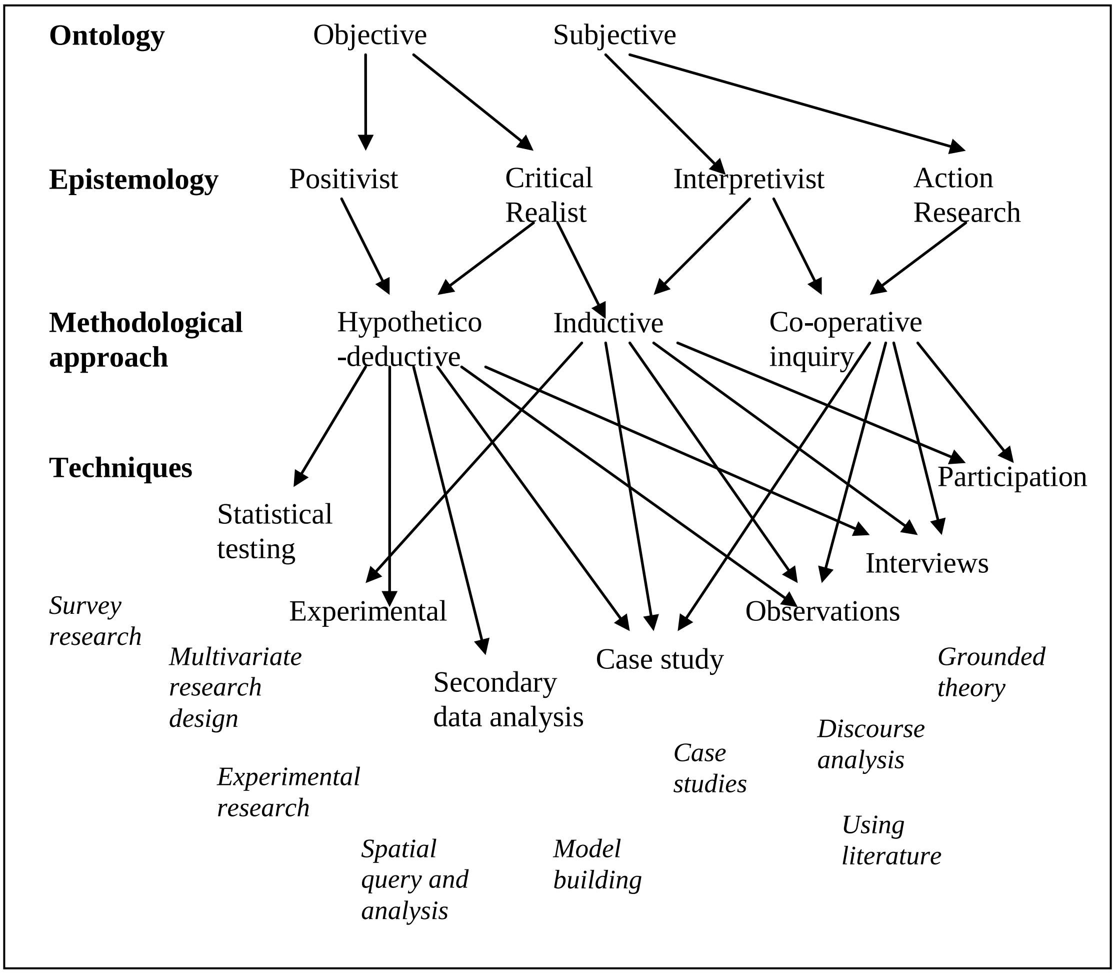

Figure 6.1: Research Design Map

Source: Adopted from (Beech, 2005)

The important features of this framework are that it is comprehensive, it gives an overview of the methodological choices the researcher has to make and this is available in a visual form, and is also aligned with the research pathway the researcher has chosen (this is also visualised in the framework) partly based on the characteristics of the research project and also based on the methodology education the researcher has received at Strathclyde. Thus, the researcher is also aware that there are other research methodology frameworks such as Rose & Sullivan (1996); Maxwell (2005); Zikmund (2003); Blessing and Chakrabarti (2009) which are comprehensive and well cited. As such, it needs to be clear that the researcher does not claim that Beech's framework is the only available framework (i.e. the best one), but that it fits the purpose of this study (i.e. a sufficiently good one).

This chapter then outlines the research design and provides a retrospective review for this study. In addition, this chapter also presents the evaluation of research quality criteria that will be used on completion of the research to ascertain its validity.

6.2 Philosophical Framework

Taylor and Bogdan (1998, p. 3) suggest that a methodological approach refers to the way in which researchers approach problems and seek answers. According to these authors, the term applies to how the research is conducted, where the assumptions, interests and purposes shape what kind of methodological approach is adopted. They further add that the central issues surrounding the methodological approach are debates over assumptions and purposes, over theory and perspective.

Additionally, Fisher (2004, pp. 33-34) describes methodological approach as, *"the study of methods and it is raises all sorts of philosophical questions about what it is possible for researchers to know and how valid their claims to knowledge might be*." Therefore, every research study needs to have a clear picture of the choice of methodological approach and to deal with philosophical questions. Consequently, this following paragraph will discuss the philosophical paradigm of the research which is closely related to how the researcher sees the world.

As noted by Zalan and Lewis (2004), the fundamental ontological question facing management researchers is whether or not reality is of an objective nature and external to the individual; that is, independent of the mind or the product of individual cognition and mind. Thus, the ontological debate concerns what do we believe about the nature of reality (Denzin & Lincoln, 2003; Patton, 2002) and how the reality is or should be constructed (Snape & Spencer, 2003).

The term epistemology refers to the philosophical theory of knowledge and is concerned with central issues such as explanation, causality, generalisation and external validity (Zalan & Lewis, 2004). The central question of the epistemological debate is how do we know what we know (Patton, 2002), how do we gain knowledge about reality, and what is the relationship between the inquirer and the known (Denzin & Lincoln, 2003; Snape & Spencer, 2003).

The ontological and epistemological standpoints to large extent determine how the researcher sees the world of her/his discipline and her/his particular research project in it. This window through which the researcher looks at her/his research is called the research paradigm. In relation, the paradigms of positivism and interpretivism lie at opposite ends of the ontological and epistemological spectrum, where positivism is based on an objective view of reality, and interpretivism on the belief that reality is subjective. In order to make this research framing easier to comprehend, the researcher contrasts these paradigms, as described in **Table 6.1**.

Table 6.1: Positivism vs. Interpretivism

Positivism	Interpretivism
Activities i. The world is independent of and unaffected by the researcher ii. Facts and values are distinct, thus making it possible to conduct value- free inquiry iii. Observations are the final arbiter in theoretical disputes iv. The methods of the natural sciences (e.g. hypothesis testing and modelling) are appropriate for the study of social phenomena because human behaviour is governed by law-like regularities.	a) The researcher and the social world impact on each other b) Facts and values are not distinct and findings are inevitably influenced by the researcher's perspective and values, thus making it impossible to conduct objective, value free research, although the researcher can declare and be transparent about his or her assumptions c) The methods of the natural sciences are not appropriate because the social world is not governed by law-like regularities but is mediated through meaning and human agency; consequently the social researcher is concerned to explore and understand the social world using both the participant's and the researcher's understanding

Source: Adapted from (Snape & Spencer, 2003)

Further, under three versions of the interpretivist paradigm are described. The difference between them is the matter of emphasis, the matter of degree of importance of various characteristics, but all belong under the umbrella of interpretivism:

(1) Social Contructionism: The social nature of the process of sensemaking underscores the additional difficulties encountered by an outsider trying to make sense of a social reality that is exterior to him or her (Noorderhaven, 2004). Social reality is constructed within communities of people that can be indicated as 'cognitive communities' such as groups of individuals working closely together in an organisation (Berger & Luckman, 1966), as the reality and science are socially constructed (Holliday, 2002). Social constructionism inquirers seek to understand contextualised meaning, to understand the meaningfulness of human actions and interaction, as experienced and construed by the actors in a given context (Denzin & Lincoln, 2003).

In line with these concepts, Easterby-Smith, Thorpe and Lowe (2002) note that the essence of social constructionism resides in the idea that reality is not objective and exterior, but is socially constructed and given meaning by people – individual and institutional agents. Hence, the task of the social scientist should not be to gather facts and measure how often patterns occur, but to appreciate the different constructions and meanings that people place upon their experience. The focus should be on what people, individually and collectively, are thinking and feeling, and the ways they communicate with each other, whether verbally or non-verbally. The features of social constructionism research is summarised in **Table 6.2,** which shows the position of this research paradigm.

Table 6.2: Implications of Social Constructionism

Features	**Social Constructionism**
The observer	Is part of what is being observed
Human interest	Are the main drives of science
Explanations	Aim to increase general understanding of the situation
Research progress through	Gathering rich data from which ideas are induced
Concepts	Should incorporate stakeholder perspectives
Unit of analysis	May include the complexity of whole situations
Generalisation through	Theoretical abstraction
Sampling requires	Small numbers of cases chosen for specific reasons

Source: Adopted from (Easterby-Smith, et al., 2002, p. 30)

(2) Hermeneutics: Is a paradigm based on the assumption that social reality has to be understood by reading it as a system of signs, such as a method of interpreting texts where in the hermeneutic circle, the interpreter moves from the understanding of single elements to an understanding of the whole (Noorderhaven, 2004). As noted by Noorderhaven (2004), "*the meaning within the text can only be understood by looking at the context, but the meaning of the context, of course, can only be grasped with reference to the meaning of the words out of which it consists".* Additionally, Patton (2002) affirms that hermeneutics is a form of phenomenological inquiry that brings to the fore the personal experience and insights of the researcher.

(3) Phenomenology: Patton (2002) states that, "*phenomenologist focus on how we put together the phenomena we experience in such a way as to make sense of the world and, in so doing, develop a worldview. There is no separate (or objective) reality for people. There is only what they know their experience is and means. The subjective experience incorporates the objective thing and becomes a person's reality, thus the focus on meaning making as the essence of human experience".* The assumption is that there is an essence (or essences) to shared experience, as phenomenological research is the study of essence (Patton, 2002).

6.3 Research Strategy

Research strategy refers to a general orientation to the conduct of business research (Bryman & Bell, 2007). Further, according to Omerod (1996) based on Dane (1990), research can be divided into five types of research strategy, which are:

(1) Exploratory research: which involves an attempt to determine whether or not a phenomenon exists; i.e. What does exist? Does it happen?

(2) Descriptive research: which involves examining a phenomenon in order to more fully define it or to differentiate it from other phenomena; i.e. What is it? How is it different?

(3) Predictive research: which involves identifying relationships that enable us to speculate about one thing by knowing about something else; i.e. What is it related to each other and how they are related?

(4) Explanatory research: which involves examining the relationship between two or more phenomena (e.g. cause-effect relationships); i.e. What causes it? How it relates to other phenomena?
(5) Action research: which refers to achieve the research result by implementing it into the reality and look at what happen; i.e. How it affects the real world and learn from that?

After discussing methodological choices of this research in the context of philosophical paradigm and research strategies within social science research, the researcher wishes to summarise the choices that are most suited to this study in the following paragraphs. These decisions will then lead the researcher to the research design process, which will be discussed further in **Section 6.4**.

The researcher background as a Malaysian with upbringing of strong social connection/family orientation with his academic background in social science in his earlier academic degree. Therefore, by nature the researcher tends to look at the world in a subjective view. Hence, the researcher believes that in this study of quality and technology management fields, it is important to go to the fundamental point, where quality and technology management begins (as to better understand the reality) in order to have a clearer understanding of where it will be in the future. The researcher focuses on searching, analysing and synthesising the literature (i.e. concept formation, values and judgements); including tracking the documents from the empirical research (Mozilla case), to immersing himself in understanding and perceiving the meaning of 'text' and the explanation behind the text. Thus, this also includes understanding the actors determine and implement quality and technology in a real study case. Following on from that, in order to predict the future vision of these two fields, the researcher looks at specific phenomenon on how quality and technology management evolved and developed into the future. Thus, the foci of the study are on the phenomena.

Based on the above and on previous discussions, this research work is located within the interpretivist group of paradigms, and focuses on understanding how the nature of the quality and technology management fields have developed to date, as well as outlining how they are likely to develop in the future.

The researcher accepts the social constructionism basis, as the researcher believes that the phenomena under study – those things that being researched are socially constructed. This is in line with Pettigrew (1992) based on Sztompka (1991) who claims that social reality is not a fixed state but a dynamic process: namely, it occurs rather than exists, as the social process is created by human agents - individual or collective - through their actions. However, this research does not investigate the process of construction, hence the researcher approaches is slightly different from this approach. As the researcher aims to look at specific phenomenon, the emerging patterns and how do they continuous (i.e. continuous improvement, partnerships, standards and leadership). For instant, in the Mozilla's case (discussed in detail in **Chapter 7**), the researcher is neither try to find out how meaning are socially constructed within the actors in the Mozilla, nor going into the dynamic process on how they negotiate the meaning of it.

On top of that, the researcher is also aware that there are some paradigms that have filtered into this research process, such as hermeneutics and phenomenological paradigms. As mentioned earlier, hermeneutics is about analysing text, which the researcher has carried out quite extensively. Also, in the Mozilla case study, the researcher actually observing the specific phenomena (i.e. continuous improvement, partnerships, standards and leadership) in a virtual world where the researcher is trying to discover the emerging patterns and how do they continuous. So partly, this work is also characterised by the hermeneutical and phenomenological approach.

In terms of research strategy, this research involves exploratory study, as it tends toward loose structures of discovering research tasks. Through exploration, this helps the researcher to develop concepts more clearly, and establish a framework and evolved theory (i.e. historical framework of quality and technology management).

All the above discussion is consistent with Zalan and Lewis (2004) who put forward the view that the methodological choices are determined not only by the ontological and epistemological stance of the researcher, but also by (1) the objective of the study; (2) the nature of the research problem; and (3) theoretical frameworks that inform the study. These should be the primary concern and will often shape the ontological and epistemological stance adopted by the researcher. The researcher therefore needs to discuss how the methodological choices are driven by each of these considerations.

6.4 Research Design

Authors such as Cooper and Schindler (2003) describe research design as the strategy for a study and the plan by which the strategy is to be carried out. It specifies the methods and procedures for the collection and analysis of data. Additionally, Easterby-Smith, et al. (2002) highlight that research designs are about organising research activities, including the collection of data, in ways that are most likely to achieve the research aim. As such, Yin (2003, p. 28) claims a research design is the logic that links the data to be collected to the initial research question.

In this research, literature is so important that it is considered a part of research design. Therefore, in designing the research, the researcher has opted to use a structured approach to selecting literature for review, and to use case study as the research design approach.

6.4.1 Structured approach to literature selection

Having reviewed the philosophical paradigms and research strategies proposed by several authors, the researcher believes it is also necessary to discuss briefly the selection criteria for the literature search, as the literature review eventually shapes the formation of ideas, direction and boundaries of the study.

In general terms, a literature review can be defined as the process of describing and critiquing relevant literature, which others have published in that particular subject area. In order to make sense of the literature, and to find out the literature pertinent to quality and technology management, the literature search begins by identifying who the gurus/experts are in those fields, and then reviewing at their published works.

According to Management Briefings Special Report No. 1202, *"good gurus possess timing the intuitive ability to fasten on to and articulate trend before others see them; and in depth knowledge of their special area which they can situate within the wider context of evolving economic and business trends"* (Anonymous, 1990). Consistent with this, the researcher believes that gurus can be defined as **those who change the paradigm, as they change the way people look from the window of the world.**

In the field of quality management, the gurus have been identified and universally agreed upon (Foster, 2001, pp. 35-49; Richardson, 1997, pp. 92-93); they are Walter Shewhart, Edward Deming, Armand Feigenbaum, Philip Crosby, Joseph Juran, Kaoru Ishikawa, Masaki Imai, Taiichi Ohno, and Genichi Taguchi. In the field of technology management, which is a relatively new field, there seems to be no universal agreement on who the gurus are.

However, the work from Davenport and Prusak (2003) identified and suggested the top 200 gurus in business disciplines, providing some insight on who are the eminent thinkers in these particular areas (i.e. quality and technology management). From this list, there are a few names that are associated with the quality and technology management field; namely Gary Hamel, C.K. Prahalad, Clayton Christensen, Joseph Juran, and Kim Clark. As such, 'thinker 50' – the web site that provides listing of the world's top 50 business gurus, which is updated every two years, also revealed similar names such as C.K. Prahalad, Gary Hamel and Clayton Christensen. See http://www.thinkers50.com/results.

Identifying the gurus and the scholars in these two fields makes it possible for the researcher to review their works, which are, mainly, in the form of books and journal articles. This allows the researcher to build on their ideas and further investigate the particular issues by looking in-depth at the literature via online database journal, such as Emerald, Science Direct, and ABI/Pro-Quest. These online databases cover journals in the area of quality management, namely International Journal of Operation and Production Management, International Journal of Quality and Reliability Management, California Management Review, Managing Service Quality, The TQM Magazine, and Journal of Operations Management.

In line with this literature review, studies conducted by (Linton & Thongpapanl, 2004; Pilkington & Teichert, 2006) claim that there are some journals to be considered as the most frequently cited and that possess relatively high journal ranking in the area of technology management; they are Research Policy, Technovation, Harvard Business Review, Journal of Product Innovation Management, Strategic Management Journal, Academy of Management Review, Research Technology Management, and International Journal of Technology Management.

On top of that, the researcher also conducted literature searches on conference proceedings, magazines and thesis, so as to update himself and deepen his insights in relation to these two fields. The purpose of conducting this comparative analysis of literature between quality and technology management in a wider context of business trends are listed below:

- To track the evolution of quality and technology management with the emphasis on principles, systems, tools and techniques, and the emerging focus of these two fields across the eras
- To track the evolution of business trends and globalisation issues
- To identify the key events of quality and technology management
- To identify the synergies, overlaps, conflicts and convergences between these two fields
- To explore the different patterns in literature of quality management, technology management and business trends
- To predict the potential future vision of quality and technology management

6.4.2 Case study research

According to Ghauri (2004), case studies are particularly well suited to new research areas, or research areas for which existing theory seems inadequate. Ghauri (2004, pp. 111-112) further suggests that case studies have the potential to deepen the understanding of the research phenomenon, as the advantage of case study is that the level of depth with which each case is investigated allows for theory building, not just theory testing. In line with this, Yin states that case studies are the preferred approach when the researcher has little control over events and when the focus is on a current phenomenon in a real-life context (Yin, 2003).

As such, Ghauri (2004, p. 114) addresses the question of, *"how many cases should be included in a study"?* Ghauri further claims that*, "the answer to this question is very difficult as there is no upper or lower limit to the number of cases to be included in a study. Many times only one case is enough"*. Further, Ghauri (2004, p. 114) based on Mintzberg (1979) claims that, *"What is wrong with a sample size of one? Why should researchers have to apologise for them?... It is the research problem and the research objectives that influence the number and choice of cases to be studied"*.

In conjunction with this, Ghauri (2004) also highlights that single cases are appropriate when a particular case is critical, as it can be used to explain or question an established theory. Hence, it is a critical case because it meets all the conditions necessary to confirm, challenge or extend the theory (Ghauri, 2004). Consistent with this, Patton (2002, p. 244) insists that, "*there are no rules for sample size in qualitative inquiry, as the sample size depends on what the researcher want to know, the purpose of the inquiry, what's at stake, what will be useful, what will have credibility, and what can be done with available time and resources"*.

In addition, Miles and Hurberman (1994) provide a description of sampling strategies in designing case studies, as illustrated in **Table 6.3** as follows.

Table 6.3: Description of sampling strategies in qualitative inquiry[1]

Type of Sampling	Purpose
Maximum variation	Documents diverse variations and identifies important common patterns
Homogeneous	Focuses, reduces, simplifies, facilitates group interviewing
Critical case	Permits logical generalization and maximum application of information to other cases
Theory based	Finds examples of a theoretical construct and thereby elaborates and examines it
Confirming and disconfirming cases	Elaborates initial analysis, seeks exceptions, looks for variation
Snowball or chain	Identifies cases of interest from people who know people who know what cases are information-rich
Extreme or deviant case	***Learning from highly unusual manifestations of the phenomenon of interest***
Typical case	Highlights what is normal or average
Intensity	Information-rich cases that manifest the phenomenon intensely, but not extremely
Politically important cases	Attracts desired attention or avoids attracting undesired attention
Random purposeful	Adds credibility to sample when potential purposeful sample is too large
Stratified purposeful	Illustrates subgroups; facilitates comparisons
Criterion	***All cases that meet some criterion; useful for quality assurance***
Opportunistic	Follows new leads; taking advantage of the unexpected
Combination or mixed	Triangulation, flexibility, meets multiple interests and needs
Convenience	Saves time, money, and effort, but at the expense of information and credibility

Source: Adopted from Miles and Hurberman (1994)

Following on from this, the author has introduced **Table 6.4 to 6.7** as follows **-** the comparison between the network organisations and their characteristics. Firstly, in order to make a proper decision on the selection of case, the researcher contrasts these network-based companies and their characteristics, as described in **Table 6.4**. All these referred companies underlined the context of future, thus these are the organisation that working in a very future oriented ways. There are three major way of how they do it; (1) Microsoft way which is a proprietary way, (2) Google way which is the mixed of open source and proprietary one (somewhere in the middle), and (3) Mozilla way which is complete open source.

[1] It should be noted that the sampling strategy used in this research is highlighted in bold and italic form, as is explained in more detail in the following paragraph.

Table 6.4: Practical examples

Company	Web Browser	Operating System	Video on Web	Level of Openness (Approach)
Microsoft	Internet Explorer	Windows series – Window 7	Windows Media Player (WMP)	Traditional proprietary
Google	Chrome	Google Chrome OS	HTML5, Adobe Flash player	Mix approach/ways
Mozilla	Firefox	Compatibility with other PC operating systems	HTML5, Adobe Flash player	Complete open source

Secondly, looking at the future context, it may consist of traditional (i.e. Microsoft Internet Explorer), extreme future – open source (i.e. Mozilla Firefox browser), and mixed (Google – Google Chrome browser). Thus, there are other organisations that operate in this context. For example, Linux operating system and video on web; HTML5, Adobe Flash player, Windows Media Player. Further, examples of web browser, operating system and video on web with respect to their level of openness are illustrated in **Table 6.5** to **Table 6.7** below.

Table 6.5: Comparison of Openness between the web browsers[2]

Web browser	Openness
Microsoft Internet Explorer	Closed (Proprietary freeware)
Google's Chrome	Open
Apple Safari	Closed
Mozilla Firefox	Open
Opera	Open

Table 6.6: Comparison of Openness between the operating system[3]

Operating system	Openness
Linux	Open
Microsoft Windows	Closed
Apple MacOS	Closed

2 Examples of the list of browser can be found at: http://windows.microsoft.com/en-US/internet-explorer/products/ie/home, http://www.google.com/chrome/intl/en/landing_chrome.html?hl=en&hl=en&brand=CHMB&utm_campaign=en&utm_source=en-ha-sea-my-sk&utm_medium=ha, http://www.apple.com/safari/, http://www.mozilla.com/en-US/firefox/new/, http://www.opera.com/

3 Examples of the list of operating system can be found at: http://www.linux.com/learn/resource-center/376-linux-is-everywhere-an-overview-of-the-linux-operating-system, http://www.microsoft.com/windows/, http://www.apple.com/macosx/what-is-macosx/, http://www.google.com/chromeos/features.html, http://hub.opensolaris.org/bin/view/Main/

Google Chrome OS - Chromium OS	Open
Sun Microsystems - OpenSolaris	Open

Table 6.7: Comparison of Openness between the video on web[4]

Video on web	Openness
W3C - HTML 5 Video	Open
Windows Media Player (WMP)	Closed
Adobe Flash player	Open

Taking into consideration all the discussions on case study design, the researcher adopted an in-depth single case study. Case study has been adopted because it tends to be more descriptive and provide richer and deeper contextual data by using a wide variety of data collection tools (Yin, 2003). The choice of a single case study (unit of analysis) is made because it is expected to advance the researcher's understanding of the research phenomena with an attempt to investigate intensively, as the researcher has more time and space to deal with the case. As such, the research sampling strategy is based on the combination of extreme/deviant case and criterion purpose, as the selected case needs to meet some criterion that the researcher is investigating (i.e. future context criteria, as discussed in **Chapter 5**). It also needs to be the exceptional case in the sense that it reflects the success story case for others to learn from.

Thus, the researcher wants to focus and be specific at the extreme event. So, the researcher chose Mozilla because they are very different and the researcher wanted to explore what is happening at the part of the world. It needs to be clear that Mozilla is one of the future ways of work - hence Mozilla is one of the companies that fit into the future. However, it is not the only way of the future. Therefore, in this study, the researcher has used Mozilla organisation as the subject of study.

In summary, the key reason for selecting Mozilla is based on the premise that they operate successfully in the future context, fulfilling the criterion purpose and providing the exceptional case.

[4] Examples of the list of video on web can be found at:
http://www.html5video.org/, http://windows.microsoft.com/en-US/windows/products/windows-media-player, http://www.adobe.com/support/flashplayer/downloads.html

Further, it is also important to have a proper design for the literature search, in order for the researcher to make the correct choice on how to conduct research, as the researcher believes that this research process begins with the selection of the literature, through to the development of a conceptual framework, and the adoption and execution of particular methodological choices. Therefore, using a proper literature search makes it possible for the researcher to draw on new ideas, concepts and frameworks, before validating these via case studies and evolving new theory.

Following on from this, the next section provides a detailed explanation on the selection of data collection methods and data analysis methods for this research.

6.5 Research Methods

Generally, the nature of the research methods can be divided into two perspectives, which are: (1) Qualitative research methods, and (2) Quantitative research methods. In line with this, Holliday (2002) discusses the characteristics between qualitative and quantitative research, which are illustrated in **Table 6.8** below.

Table 6.8: Characteristics between quantitative and qualitative research

Quantitative research	Qualitative research
Activities i. Count occurrences across a large population ii. Uses statistic replicability to validate generalisation from survey samples and experiments	a) Look deep into the quality of social life b) Locate the study within particular settings which provide opportunities for exploring all possible social variables; and set manageable boundaries c) Initial foray into the social setting leads to further, more informed exploration as themes and focuses emerge
Beliefs iii. Conviction about what it is important to look for iv. Confidence in established research instruments v. Reality is not so problematic if the research instruments are adequate; and conclusive results are feasible	d) Conviction that what it is important to look for will emerge e) Confidence in the ability to devise research procedures to fit the situation and the nature of the people in it, as they are revealed f) Reality contains mysteries to which the researcher must submit, and can do no more than interpret

Typical steps	
vi. First decide the research focus (e.g. testing a specific hypothesis) vii. Then devise research instruments (e.g. survey questionnaire or experiment) viii. Then approach the subject	g) Decide the subject is interesting (e.g. in its own right, or because it represents an area of interest) h) Explore the subject i) Let focus and themes emerge j) Devise research instruments during process (e.g. observation or interview)

Source: Adapted from (Holliday, 2002)

The purpose of this study is to gain in-depth understanding how quality management and technology management fields have developed and evolved to date, how they will develop into the future, and identify potential opportunities for convergences between these two fields. In order to achieve this understanding, this research has been designed in the qualitative approach, as most of the data in this research is in the form of qualitative. This enables the researcher to interpret meaning, make sense of data, and eventually produce new ideas and concepts in order to establish a new and evolved concept towards theory building.

Accordingly, qualitative methods are the practical purposes in the ways of finding out what people do, know, think, and feel by observing, interviewing, and analysing documents (Patton, 2002), and understanding people from their own frames of reference and experiencing reality as they experience it (Taylor & Bogdan, 1998).

6.5.1 Data Collection Methods

There are several methods that can commonly be used to collect data for research purposes. Accordingly, Patton (2002) provides a good understanding on the data collection methods and suggests that, qualitative findings grow out of three kinds of data collection methods, which are:

(1) Interviews: Interviews yield direct quotations from people about their experiences, opinions, feelings, and knowledge. Data consists of verbatim quotations with the sufficient context to be interpretable.

(2) Observations: Fieldwork descriptions of activities, behaviour, actions, conversations, interpersonal interactions, organisational or community processes, or any other aspect of observable human experience. Data consisting of field notes are

rich, detailed descriptions, including the context within which the observations were made.

(3) Documents: Written materials and other documents from organisational, clinical, or programs records; memoranda and correspondence; official publications and reports; personal diaries, letters, artistic works, photographs, and memorabilia; and written responses to open-ended surveys. Data consisting of excerpts from documents captured in a way that records and preserves context.

Table 6.9 as follows, highlights the most commonly used methods in the research.

Table 6.9: Descriptions of data collection methods[5]

Methods	**Descriptions**	**References**
Interviews	As a form of conversation with a purpose	Fontana and Frey (2003); Legard, Keegan and Ward (2003); Wilkinson and Birmingham (2003); Easterby-Smith, Thorpe and Lowe (2002)
Focus groups	Focus group interview is an interview with a small group of people on a specific topic where groups are typically 6 to 10 people with similar backgrounds. Focus group presents a more natural environment because participants are influencing and influenced by others, just as they are in real life	Finch and Lewis (2003); Patton (2002); Zikmund (2003)
Observation	The systematic process of recording the behavioural patterns of people, objects and occurrences as they are witnessed	Angrosino and Perez (2003); Denzin and Lincoln (2003); Wilkinson and Birmingham (2003); Zikmund (2003); Easterby-Smith, Thorpe and Lowe (2002)
Survey	A research technique in which information is gathered from a sample of people by use of a questionnaire or interview; a method of data collection based on communication with a representative sample of individuals. Additionally, it can be done in the various way such as drop-off survey, fax survey, experience survey and e-mail survey	Holliday (2002); Zikmund (2003); Baker (2003)
Visual/ Interactive Media	The used of photography, motion pictures, interactive CDs, CD-ROMs, and virtual reality as ways of forging connections between human existence and visual perception. These forms of visual representation constitute different ways of recording and documenting what passes as social life	Harper (2003)

[5] It should be noted that the one that been used in this research are shown in bold and italic form, as the explanation followed thereafter the table.

Watching Streaming media	Multimedia content, such as audio or video that is made available in real time over the Internet (World Wide Web) or a corporate intranet	Zikmund (2003)
Experiment	A research method in which conditions are controlled so that one or more variables can be manipulated in order to test a hypothesis. Experiment is a research method that allows evaluation of causal relationships among variables	Holliday (2002); Zikmund (2003); Baker (2003)
Scanning Document	Records, documents, artifacts, and archives, constitute a particularly rich source of information about many organisations and program	Hodder (2003); Patton (2002); Zikmund (2003)

After considering all the options of data collection methods, the researcher decided to use the mixed methods for this study. The details of data collection according to phase are illustrated in the following **Table 6.10** and the justification of this decision is discussed thereafter the table.

Table 6.10: Method of data collections by phase

Phases	Descriptions
Phase 1 – Conceptual Phase	The used of: • Literature review • Expert opinion survey • Face-to-face interview with scholar
Phase 2 – Empirical Phase	The used of: • Primary data collection from official company websites • Primary data collection from 'hand-on-trial observation' • Secondary data from journal article and magazine

In the early study (i.e. conceptual phase), the researcher used the method of an electronic survey (expert opinion survey) which was sent respectively to the identified scholars in the area of technology management in order to elicit what would be the key principles of technology management. Following on from that, the researcher was fortunate to have a discussion, which was carried out in the form of a face-to-face interview, with the founder of International Associate Management of Technology (IAMOT); Professor Dr. Tarek Khalil, during the European Management of Technology (EUROMOT) Conference on 7th September 2009. The face-to-face interview was carried out in order to cross-check the earlier findings of the expert opinion survey, as this provides the opportunity to refine the outcomes. The details of these have already been mentioned in **Chapter 3**.

By using observation in the empirical phase, the researcher is better able to observe Mozilla official websites by understanding the text, comments, blogs and latest news around the communities of practice in Mozilla, and deriving the meanings from all these sources. Further, the researcher also needs to be familiar with the stream of Mozilla products (i.e. Firefox) and programs, including downloading web browser (Firefox) and the installation of add-ons (extensions of web browser) from third-party software developers (discussed in detail in **Chapter 7**). To cope with all these activities, the researcher opted for a 'hands-on trial observation', as the researcher used this term to reflect his experiences through hands-on observation in the context of the virtual environment.

It needs to be stated that in a common research practice, these two methods; (1) Primary data collection from official company websites and (2) Primary data collection from 'hands-on trial observation' are similar to observation method, where the researcher observes and experiences the interested phenomena (i.e. changes and the emerging themes and pattern). In doing so, the researcher is actually observing and experiencing the dynamics of communities when visiting the official websites in real time in order to understand and make sense of it. This is an accurate source of data since Mozilla's organisation is an open source project (discussed in detail in **Chapter 7**), in which the content and information is open to public. Therefore, this makes it possible for researcher to immerse himself through the use of this openness concept in accessing Mozilla's documents (primary data) such as the financial annual report[6], minutes of meetings[7] and electronic newsletter[8].

Further, in order to gain a clearer understanding on the implementation of quality and technology management, specifically in the areas of continuous improvement, including the standards, leaderships and supplier relationships/partnerships in the Mozilla case, the researcher also decided to use the secondary documents, such as uploaded media (i.e. interviews with Mozilla's chairman) and articles from magazines and journals.

[6] Mozilla financial documents including financial annual report can be accessed at: www.mozilla.org/foundation/documents/
[7] Mozilla minutes of meetings can be found at: https://wiki.mozilla.org/WeeklyUpdates
[8] Mozilla news and activities can be found at: http://www.mozilla.com/en-US/press/

As mentioned in the above discussion, there are five key data collection methods that are used in this study (mixed methods), which are: (1) Primary data from official company websites (2) Primary data from 'hands-on trial observation' (3) Primary data from expert opinion survey via e-mail (electronic mail survey) (4) Primary data from face-to-face interview with scholar and (5) Secondary data from journal article and magazines.

In summary, in conducting this research the author has accessed official company documentation. The fact that the author has accessed the information through the web does not matter. As an alternative the author could has used interviews, as one may argue that using interviews in the selected company may add additional value. However, the researcher contents that, because of the nature of this case study, the observation itself included an online discussion where the researcher had accessed and read about other people's opinion, which carries the same function as interviews. The second point is that, watching streaming data also allowed the researcher to understand what people were thinking and saying. So the need of additional value for conducting interviews will be minimum. In addition, conducting additional interviews, i.e. face-to-face interviews with the key people in the network, would not, in the author's opinion, have provided much additional value or make much difference. This also raises the point *how we are going to interview networks*? On the one hand, by only interviewing people (i.e. Mozilla developers) in the company will be considered as 'a box sided'. On the other hand, by observing people in the networks provided a balance view about Mozilla. It is not just about people in the Mozilla organisation, but also including and tapping into Mozilla's communities of practice.

6.5.2 Data Analysis Methods

In terms of definition, data analysis refers to the practical application of such procedures in analysing social science data (Rose & Sullivan, 1993, 1996). In addition, Patton (2002, p. 432) suggests that, "*qualitative analysis transforms data into findings. No formula exists for that transformation. Guidance, yes. But no recipe".* In line with this, Spencer, et al., (2003) claim that, "*unlike quantitative* *analysis, there are no clearly agreed rules or procedures for analysing qualitative data".*

Several approaches within qualitative analysis are presented in **Table 6.11** as below.

Table 6.11: Approaches within qualitative analysis[9]

Terms	**Descriptions**	**References**
Content Analysis (CA)	The content and context of documents are analysed and the themes are identified, with the researcher focusing on the theme is treated or presented and the frequency of its occurrence	Spencer, Ritchie and O'Connor (2003, p. 200); Zikmund (2003); Patton (2002, p. 453)
Ethnographic accounts	Largely descriptive, which detail the way of life of particular individuals, groups or organisations	Spencer, Ritchie and O'Connor (2003, p. 200); Patton (2002, p. 81)
Life histories	Can be analysed as single narratives, as collections of stories around common themes, or quarried to construct an argument based on comparison between different accounts	Spencer, Ritchie and O'Connor (2003, p. 200); Patton (2002, p. 478); Taylor and Bogdan (1998, p. 161)
Narrative analysis	Identifies the basic story, which is being told and focuses on the way an account or narrative is constructed, as well as the meaning of the story or plot	Spencer, Ritchie and O'Connor (2003, p. 200); Patton (2002, p. 478)
Conversation analysis	Focuses on the structure of conversation classifies interaction in terms of key linguistic systems	Spencer, Ritchie and O'Connor (2003, p. 200)
Discourse analysis	Concerned with the way knowledge produced within a particular discourse using distinct language or through the adoption of implicit theories in order to make sense of social action	Spencer, Ritchie and O'Connor (2003, p. 200)
Analytic induction	Aims to identify deterministic laws and the essential character of phenomena, involving an iterative process of defining a problem, formulating and testing hypothesis, then reformulating the hypothesis or redefining the problem until all cases fit the hypothesis	Spencer, Ritchie and O'Connor (2003, p. 201); Patton (2002, pp. 94-95)
Policy and evaluation analysis	Analysis is targeted towards providing 'answers' about the contexts for social policies and programmes and the effectiveness of their delivery and impact	Spencer, Ritchie and O'Connor (2003, p. 201)
Thematic analysis/content analysis (not CA)	Aims to examines the incidence such as themes, issues, words, phrases, etc in a text, as the key focus is on the themes or issues in the text that the researcher intends to analyse – i.e. looking for	Wilkinson and Birmingham (2003, pp. 69-70)

[9] It should be noted that the one that the analysis used in this research is highlighted in bold and italic form, and explained thereafter.

	emergent patterns of meaning in text	
Pattern matching	Aims to compare an empirically based pattern with a predicted one	Yin (2003, p. 116); Ghauri (2004, p. 118)
Time series/ chronology/ historical analysis	Aims to describe what happened chronologically, over time, telling the story from beginning to end. In which the compiling of chronological events is also frequent techniques in case studies and may be considered a special form of time series analysis	Yin (2003, p. 125); Patton (2002, p. 439); Ghauri (2004, p. 118)
Cause and effect analysis/ Outcomes matrix	Elucidating causal linkages between processes and outcomes in which to make comparisons, considering causes, consequences and relationships	Patton (2002, pp. 471, 478-479); Ghauri (2004, p. 118)

Having reviewed the approaches of data analysis, **Table 6.12** summarises the selected data analysis methods for this research and justification for their use.

Table 6.12: Justification of selected data analysis

Method of analysis selected	**Justification**
1. Thematic analysis/content analysis (not CA)	- To identify the emerging themes of phenomena of quality and technology management (i.e. looking for emergent patterns of meaning in text)
2. Pattern matching	- To provide clarity of identified themes of phenomena of quality and technology management
3. Time series/chronology/historical analysis	- To identify the key event of quality and technology management - To investigate the historical event of Mozilla case study - To investigate the evolution of principles, systems, tools and techniques and the emerging focus between quality and technology management
4. Cause and effect analysis/Outcomes matrix	- To investigate the relationships between principles of quality and technology management and the impact of future context

Based on the above discussion and the justification of choice, the researcher adopted four methods of analysis, namely: (1) Thematic analysis/content analysis (not CA), (2) Pattern matching, (3) Time series/historical analysis, and (4) Causal and effect analysis/Outcomes matrix. As Holliday (2002) suggests, moving chronology over time allows the researcher to organise the data into themes, look for the patterns, see the relationships and make sense of it. All of these methods of analysis enable the researcher to link data to propositions and criteria for the purpose of interpreting findings towards theory building.

6.5.3 Validity, reliability and generalisation

According to Lewis and Ritchie (2003, p. 271), validity of findings or data refers to the correctness or precision of a research reading, while reliability is concerned with the replicability of findings and whether or not they would be repeated if another study, using the same or similar methods, was undertaken. Likewise, reliability also refers to consistency and dependability (Easterby-Smith, et al., 2002). In qualitative research, it concerns the extent to which the phenomena under observation is being accurately reflected, as perceived by the study population (Lewis & Ritchie, 2003, p. 285).

As such, the analysis needs to be complemented with triangulation. In general terms, triangulation is a way of examining insights gleaned from different informants or different sources of data. By drawing on other types and sources of data, observers also gain a deeper and clearer understanding of the setting and the people being studied (Taylor & Bogdan, 1998). Consistent with this, Patton (2002, p. 247) also claims that triangulation strengthens a study by various methods, which means using several kinds of methods or data.

Likewise, Lewis and Ritchie (2003, p. 275), note that triangulation assumes that the use of different sources of information will help both to confirm and to improve the clarity or precision of a research finding. This also allows the data to be explored from a different viewpoint or perspective, and in doing so, the risk of bias could be reduced.

In a classic example, Denzin (1978) suggests that triangulation consists of:

1. Methods triangulation: comparing data generated by different methods (e.g. qualitative and quantitative)
2. Triangulation of sources: comparing data from different qualitative methods (e.g. observations, interviews, documented accounts)
3. Triangulation through multiple analysis: using different observers, interviewers, analysts to compare and check data collection and interpretation
4. Theory triangulation: looking at data from different theoretical perspectives

Apart from triangulation, the key issue in social science research concerns the ability to replicate the findings, and whether or not they could be repeated using identical or similar methods (Lewis & Ritchie, 2003, p. 271). As in the social sciences, repeatable experiments are difficult to achieve and virtually all knowledge gained by social science is heavily meaning bearing (Checkland & Scholes, 1999, p. 3).

In order to compensate for this problem, (Checkland & Holwell, 1998; Checkland & Scholes, 1999) introduced the terms ‘recoverability’ and ‘learning from experience’. As noted by Checkland and Scholes (1999), the key idea underpinning recoverability is that research should be conducted in such a way that the whole process is recoverable by anyone interested in scrutinising its findings. This means declaring explicitly, at the start of the research, the intellectual frameworks and processes which will be used to define what counts as knowledge in this piece of research. In doing so, this makes it possible for outsiders to follow the research and see whether they agree or disagree with the findings, and if they disagree, a well-informed discussion and debate can then follow (Checkland & Scholes, 1999, p. A40).

Checkland and Scholes (1999, p. 4) further note that, ‘learning from experience’ “*is the idea that it is probably worth trying to find ways of formally operating the learning cycle in which purposeful action is taken in real-world situations in order to bring about what are deemed to be improvements by those carrying out the process; and secondly to the idea that systems thinking (learning system) may be helpful in this task”.* On the one hand, this eventually leads to the endless cycle from experience to purposeful action and on the other hand, a long steady series of experiences can, in principle, yield lessons of some general validity (Checkland & Scholes, 1999, p. 275).

Inevitably, the importance of validity and reliability analysis can be seen in the publication of several authors, such as (Bryman & Bell, 2007; Lewis & Ritchie, 2003; Yin, 2003; Zikmund, 2003), who also highlight that validity can be classified into three main elements, which are:
(1) Construct validity: the ability to establish correct operational reading for the concepts being studied

(2) Internal validity: the ability to make predictions or inferences

(3) External validity: the ability to generalise the results to the other groups within the population or to other contexts or settings

As such, at the end of the analysis of this research, the novelty is to produce a theory (i.e. generalisation towards theory building). According to Langley (1999) theory building involves three processes: (1) induction (data-driven generalisation), (2) deduction (theory-driven hypothesis testing), and (3) inspiration (driven by creativity and insight). Langley (1999) further claims that inspiration draws indiscriminately on formal data, experience, *a priori* theory, and common sense, as it succeeds in creating new and plausible connections between each of these, that can then be made explicit as theoretical products, and thereafter exposed to the scrutiny of others, and verified. Similarly, authors such as Baker (2003); Bryman and Bell (2007); Easterby-Smith, et al., (2002) and Silverman (2010), further highlight the novelty of research, which they claim needs to be practical as well as theoretical in nature.

In relations, Lewis and Ritchie (2003) put forward the argument that generalisation is often discussed in two linked but rather different contexts (i.e. theoretical and empirical generalisation). Accordingly, theoretical generalisation is about generation of theoretical concepts or propositions, which are deemed to be of wider, or even universal, application, as the conclusions are drawn from features or constructs developed in a single study which are then utilised in developing wider theory. Empirical generalisation concerns the application of findings from qualitative research studies to populations or settings beyond the particular sample of the study, where some authors prefer the terms 'external validity' to describe this (Lewis & Ritchie, 2003).

To help with this clarification, they further suggest that generalisation can be seen as involving three linked but separate concepts as stated, as follows:

• *"First, what we have termed* ***representational generalisation****: the question of whether what is found in a research sample can be generalised to, held to be equally true of, the parent population from which the is drawn".*

• *"Second, the question of whether the findings from a particular study can be generalised, or inferred, to other settings or contexts beyond sampled one. We have called this* ***inferential generalisation****".*

• *"Third,* ***theoretical generalisation****, which draws theoretical propositions, principles or statements from the findings of a study for more application".*

In addition, Stierand and Dorfler (2010) based on Morse (1999) argued that in the subjective research, "*it is impossible to claim generalisability for a well-defined area of validity"*. However, in the subjective research, the generalisation is achieved through learning. *"It is the fit of the topic or comparability of the problem that is of concern…it is the knowledge that is generalised"* (Morse, 1999, p. 6). Further, Stierand and Dorfler (2010) summarise this idea in the following quotation, "*the reason why researchers were able to generalise (i.e. apply their findings to contexts other than the one researched) is that they have learned about the essence of the phenomenon of their investigation and thus, they were able to make better sense of this phenomenon even when it appeared in a different context. Consequently, generalising can be seen as iterative learning from investigating the extraordinary"*.

Based on the above discussion and the justification of choice, in this research, it is expected that the researcher may achieve validity through methods triangulation based on (Denzin, 1978; Patton, 2002) as the researcher had obtained the data by using five different data collection methods. Additionally, the researcher also opted Checkland's 'recoverability' and 'learning from experience' concept in dealing with reliability and validity issues (Checkland & Holwell, 1998; Checkland & Scholes, 1999). The researcher believes that, through the process of learning from experience, the researcher is better able to make sense of his experiences whilst engaging with real world cases (i.e. Mozilla), as this study as a whole represented a process of learning. As such, in this subjective kind of research (i.e. interpreting the phenomena of study), it is also expected that the generalisability works through learning (Morse, 1999; Stierand & Dorfler, 2010), as the findings may also apply in other cases.

6.6 A retrospective review for this study

In this chapter, the researcher has discussed the important issues in deciding the appropriate methodological approach for this research. The researcher has also identified that the study fits within the interpretivist paradigm. The researcher accepts the social constructionism basis, and believes that phenomena being researched are socially constructed. The researcher is also aware that there are some paradigms that have influenced this research process, such as hermeneutics and phenomenological.

On top of that, the researcher concluded that the research is an exploratory type of research, as it fulfils the research purpose (i.e. explorative and predictive). The researcher has also chosen his research design through case studies research and literature review.

Taking into account the discussions regarding the case study design, the researcher adopted a single case-study design based on the argument put forward by (Ghauri, 2004; Patton, 2002; Yin, 2003). Hence, the choice was made because it was expected to advance the researcher's understanding of the research phenomenon with an attempt to investigate intensively, as the researcher would have more time and space to deal with the case. In addition, this is due to the fact that not many companies operate in the future context and the case chosen is an exemplary - operate successfully in the future context, fulfilling the criterion purpose and providing the exceptional case.

Throughout the research process, the researcher opted for five key data collection methods (mixed methods) using: (1) Primary data from official company websites, (2) Primary data from 'hands-on trial observation', (3) Primary data from expert opinion survey via e-mail (electronic mail survey), (4) Primary data from face-to-face interview with scholar, and (5) Secondary data from documents (i.e. journal article and magazines). The researcher also adopted four methods of analysis, namely: (1) Thematic analysis/content analysis (not CA), (2) Pattern matching, (3) Time series/historical analysis, and (4) Cause and effect analysis/Outcomes matrix. All of these methods of analysis enable the researcher to link data to propositions and interpret findings towards theory building.

The researcher was also aware of and agreed with the arguments put forward by (Mann, 1981 ; Rose & Sullivan, 1993, 1996) that there is not one methodological approach when undertaking research, but there is one 'socio-logic', which involves the knitting together of theory, concept formation, values and judgements, operationalisation, observations, data analysis, insights, the derivation of hypotheses, and back to theory again. **Figure 6.2** as follows, illustrates the socio-logic of research – the methodological stages of the research.

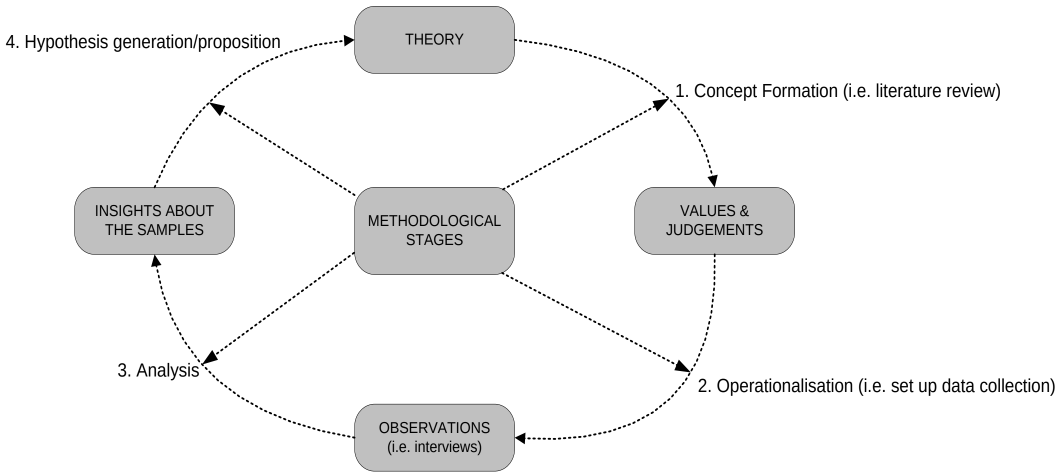

Figure 6.2: Socio-logic of research

Source: Modified from (Rose & Sullivan, 1993, 1996; Wallace, 1971)

As such, based on the framework of (Beech, 2005), as previously mentioned in **Section 6.1**, the summary of the adopted methodological choices of this research is illustrated in **Figure 6.3** as follows.

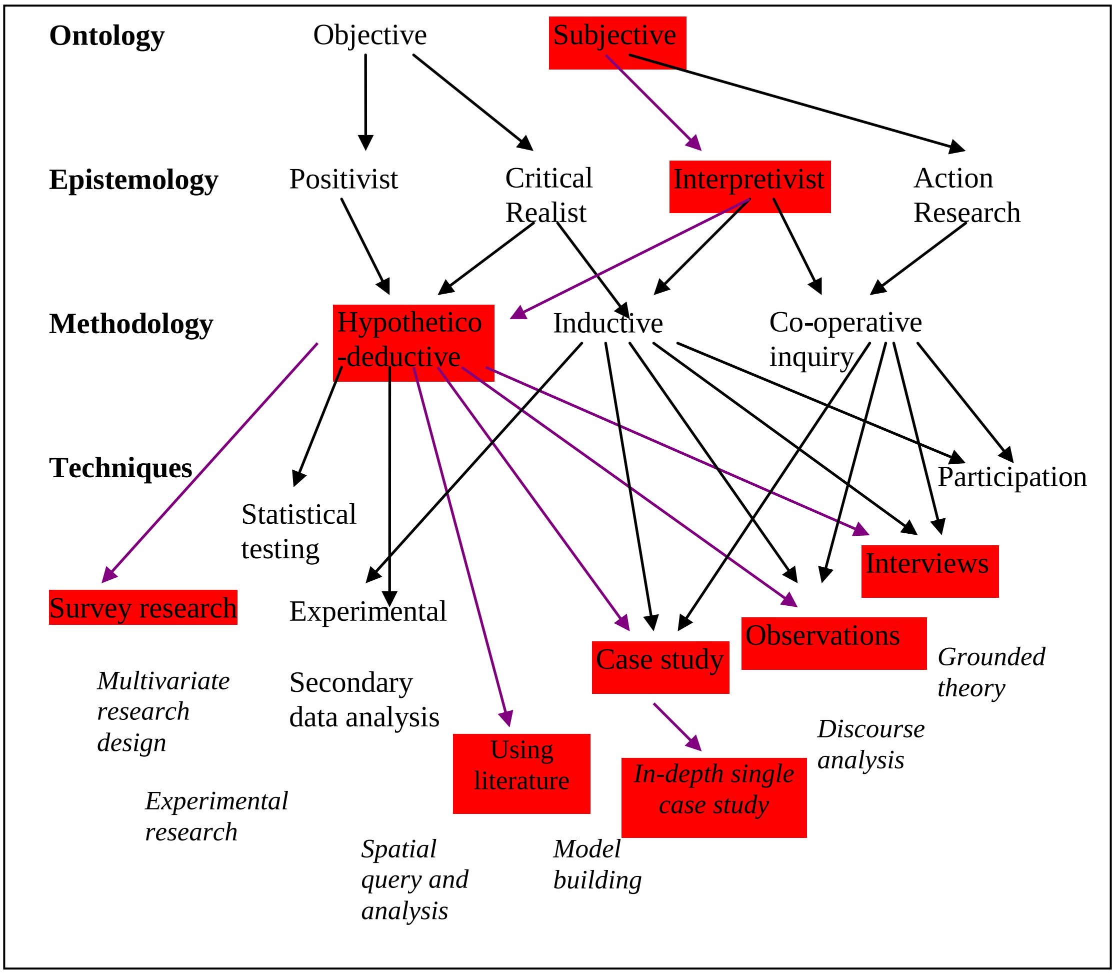

Figure 6.3: The research design map for this research

Source: Adapted from (Beech, 2005)

Also, the researcher personally felt that if the researcher had the chance to repeat the research process, the researcher may also take some other considerations into account in order to strengthen and deepen the research; these could include:

- To e-mail (electronic survey) to more scholars in the area of technology management in order to elicit what would be the TM principles
- To conduct a focus group (among the scholars) in order to derive an understanding of how quality and technology management may evolve and develop in the future, and the potential convergences between these two fields
- To conduct multi-case studies, as the researcher is expecting more companies will be ready and aligned with the future context (discussed detail in **Chapter 5**) in the years ahead

- To conduct more face-to-face interviews with experts from the selected cases

The research process of this study is presented in **Figure 6.4**, where the shaded boxes represent the output throughout this research process.

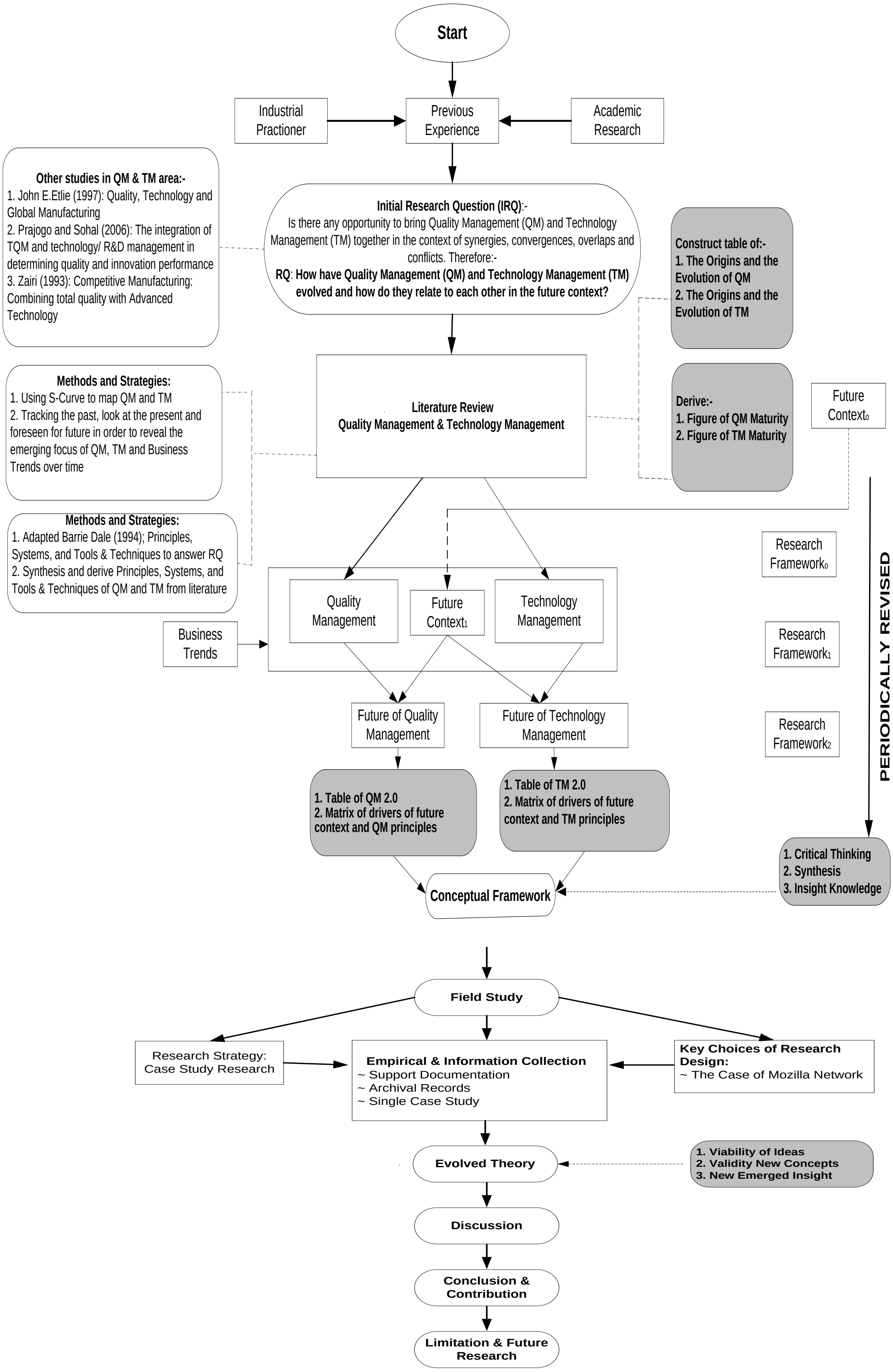

Figure 6.4: The research process of this study

Note: Boxes in **shade** represent the outputs of the research

6.7 Conclusions

Having discussed the methodological choices adopted for this research, including the philosophical paradigms, research strategy, research design and research methods, the researcher also felt that it was necessary to set up some research quality criteria to be fulfilled. The criteria used in this study are illustrated in **Table 6.13** below with the key reason for having the criteria (self-assessment criteria) is to assess the quality of the research process as well as the final outcomes, which will be discussed further in the following **Table 8.7** in **Chapter 8**.

Table 6.13: Research quality criteria for this research

Criterion	Details	References
Contribution to knowledge	The ability of this research to demonstrate some kind of original contribution to the field (i.e. new theories and ideas)	Easterby-Smith, Thorpe and Lowe (2002); Silverman (2010)
Validity: Construct validity	The ability to establish correct operational reading for the concepts being studied	Yin (2003); Zikmund (2003); Bryman and Bell (2007)
Internal validity	The ability to make predictions or inferences	Yin (2003); Lewis and Ritchie (2003); Bryman and Bell (2007)
External validity	The ability to generalise the results and apply them to the other groups within the population or to other contexts or settings	Zikmund (2003); Lewis and Ritchie (2003); Yin (2003); Bryman and Bell (2007)
Reliability: Recoverability	The ability to conduct research in a way that the whole process is subsequently recoverable by anyone interested in scrutinising the research, as this makes it possible for outsiders to follow the research and see whether they agree or disagree with the findings	Checkland and Scholes (1999); Checkland and Howell (1998)
Learning from experience/ Learning process	The ability to make sense of experiences (i.e. the complex happenings throughout the study), so that the study as a whole represents a process of learning	Checkland and Scholes (1999); Checkland and Howell (1998)

In the next chapter, the research discusses the analyses and findings of the network case using the chosen data collection and data analysis methods.

CHAPTER 7

Mozilla Case Study

7.1 Introduction

This chapter discusses the analyses and findings of the network case. The aim of this chapter is to use the Mozilla case study to validate the principles of quality and technology management, as well as providing a deeper insight into how the predicted trends actually occur in practice. At present, the most mature product for Mozilla is Firefox. Therefore, the researcher focuses mainly on the Firefox product, but also considers other aspects of business and divisions/product streams that are significant in this context. The above-mentioned aim will be achieved by mapping the case of Mozilla onto this framework and discussing the outcomes.

7.2 Overview of Mozilla

Mozilla is a global community of people who believe that openness, innovation and opportunity are key to the continued health of the internet. Mozilla position themselves as:

- *"A global community of thousands who sincerely believe in the power of technology to enrich people's lives".*
- *"A public benefit organisation dedicated not to making money but to improving the way people everywhere experience the Internet".*
- *And "An open source software project whose code has been used as a platform for some of the Internet's most innovative projects".*

The mission of the company is summarised in the following quotation:

"The common thread that runs throughout Mozilla is our belief that, as the most significant social and technological development of our time, the Internet is a public resource that must remain open and accessible to all. With this in mind, our efforts are ultimately driven by our mission of encouraging choice, innovation and opportunity online".

Source: http://www.mozilla.com/en-US/about/whatismozilla.html

In order to better understand Mozilla, **Table 7.1** below provides some descriptions of its subsidiary organisations.

Table 7.1: Mozilla Descriptions

Terms	Descriptions	References
Mozilla	Mozilla the principal trademark representing the foundation and the official releases of internet client software developed through open source project.	www.mozilla.org/mission.html
Mozilla org.	Mozilla org. is a group chartered to act as the virtual meeting place for the Mozilla code where that group is overseen by Mozilla Foundation.	www.mozilla.org/mission.html
Mozilla Foundation	The Mozilla Foundation is a non-profit organisation that sponsors the Mozilla project and devotes its resources to promoting openness, innovation and opportunity on the Internet. Mozilla Foundation does this by supporting the community of Mozilla contributors and by assisting others who are building technologies that benefit users around the world.	http://www.mozilla.org/foundation/
Mozilla Corporation	Mozilla Corporation is a taxable subsidiary that serves the non-profit, public benefit goals of its parent, the Mozilla Foundation, and is responsible for product development, marketing and distribution of Mozilla products.	http://www. mozilla.org/reorganization/

7.2.1 Mozilla Aim

The Mozilla community, organisation and technology are all focused on a single goal: **Making the Internet better for everyone.** In order to achieve this, Mozilla states that:

"*We use a highly transparent, extremely collaborative process that brings together thousands of dedicated volunteers around the world with our small staff of employees to coordinate the creation of products like the Firefox web browser. This process is supported by the Mozilla Corporation, which is a wholly-owned subsidiary of the non-profit Mozilla Foundation*[10]*"*.

7.2.2 Background of Mozilla

Mozilla was the original code name for the product (open-source project) that came to be known as Netscape Navigator back in February 1998[11]. Hamm (2008) summarises the story of Mozilla in the following quotation, *"Netscape*

[10] Mozilla aim, available at: http://www.mozilla.com/en-US/about/whatismozilla.html
[11] Background of Mozilla, available at: http://www.mozilla.org/about/history.html

Communications the early leader in Internet software was under relentless assault by Microsoft, which feared it might lose out in the shift toward Web-based computing. To turn the tables, Microsoft began giving away Internet Explorer for free and integrating the browser with its dominant Windows operating system. That gutted Netscape's business model of selling the Netscape Navigator browser to businesses. Microsoft's approach landed it in hot water with the Justice Dept., which accused the company of using monopoly power to control the market. The strategy also inflicted the intended damage on Netscape, so much so that it chose a radical course. It stopped charging for Navigator and published the source code for the software. The hope was that thousands of volunteer programmers would use the open-source code to add neat features to Navigator, helping Netscape out-innovate Microsoft and maintain its market lead. Yet the unit created to oversee the open-source initiative named the Mozilla Organisation after Netscape's emblem. After American Online (AOL) bought a battered Netscape in 1999 and later merged with Time Warner (TWX), the tiny project got lost within the giant corporation, where it didn't get the funding and management attention it needed. And there was another issue: The Netscape code was seriously flawed. The browser needed to be rewritten from scratch".

Further, Hamm (2008) points out that "*it wasn't until late 2004 that the organisation pulled things together and released Firefox 1. By then, AOL had spun out the project as an independent non-profit entity. The newly created Mozilla Foundation drew seed funding from AOL, IBM, Sun Microsystems (JAVA), and Lotus Development founder Mitch Kapor. It wasn't until after the foundation created a for-profit subsidiary in mid-2005 that Firefox's market share began to grow quickly. Mozilla was freer than the parent organisation to enter business relationships that generated revenue mostly by taking fees from Google and other search engines for embedding their search bars in the Firefox browser".*

7.2.3 Mozilla Structure

The uniqueness of Mozilla can be seen in its organisational structure. In the early years, Mozilla only had an internal staff of less than 15 people (MacMillan, 2009b). In August 2005, there were only three employees in the Mozilla Foundation and less than forty employees in the Mozilla Corporation[12]. Despite having had fewer than 100 staff for most of its existence, the grassroots organisation managed to break Microsoft's lock on the Web browser market (Hamm, 2008). Further, the structure of the Mozilla Foundation and the Mozilla Corporation are illustrated as below:

Board of Directors and Staff for Mozilla Foundation:-

Board of Directors

- Mitchell Baker, Chair
- Brian Behlendorf
- Brendan Eich
- Joi Ito
- Bob Lisbonne

Staff

- David Boswell
- Katie Guernsey
- Chelsea Novak
- Gerv Markham
- Mark Surman
- Matt Thompson
- Sara Yap
- Alan Gunn
- Jim Cook
- Brett Gaylor
- Nathaniel James

Source: http://www.mozilla.org/foundation/about.html, as retrieved on November 1, 2010.

The Mozilla Corporation Board of Directors is appointed by and responsible to the Mozilla Foundation Board of Directors.

[12] Mozilla reorganisation, available at: http://www.mozilla.org/reorganization

Mozilla Corporation Board of Directors:

- Mitchell Baker (Chairperson)
- Reid Hoffman
- Ellen Siminoff

Mozilla Corporation Management Teams:

- John Lilly, Chief Executive Officer
- Brendan Eich, Chief Technical Officer
- Jim Cook, Chief Financial Officer
- Chris Beard, Chief Innovation Officer
- Mike Shaver, Vice President of Engineering
- Justin Fitzhugh, Vice President of Engineering Operations
- Jay Sullivan, Vice President of Mobile
- Dan Portillo, Vice President of Organisational Development
- Harvey Anderson, Vice President, General Counsel

Source: http://en.wikipedia.org/wiki/Mozilla_Corporation, as retrieved on August 11, 2010.

7.2.4 Mozilla Culture

Mozilla promotes free culture and open source development of the internet as a public resource. *"The free culture movement is a social movement that promotes the freedom to distribute and modify creative works in the form of free content by using the internet and other forms of media*[13]*".*

Mozilla devotes a significant amount of time and resources into fostering a healthy ecosystem for communities that promote people's ability to freely access, modify and distribute software and other creative works[14]. The following quotation illustrates the commitment of Mozilla's striving free culture:

[13] Source: http://en.wikipedia.org/wiki/Free_Culture_movement
[14] Mozilla free culture and open source development at http://www.mozilla.org/causes/free.html

- *"The Internet is an integral part of modern life – a key component in education, communication, collaboration, business, entertainment and society as a whole".*
- *"The Internet is a global public resource that must remain open and accessible".*
- *"The Internet should enrich the lives of individual human beings".*
- *"Individuals' security on the Internet is fundamental and cannot be treated as optional".*
- *"Individuals must have the ability to shape their own experiences on the Internet".*
- *"The effectiveness of the Internet as a public resource depends upon interoperability (protocols, data formats, content), innovation and decentralised participation worldwide".*
- *"Free and open source software promotes the development of the Internet as a public resource".*
- *"Transparent community-based processes promote participation, accountability, and trust".*
- *"Commercial involvement in the development of the Internet brings many benefits; a balance between commercial goals and public benefit is critical".*
- *"Magnifying the public benefit aspects of the Internet is an important goal, worthy of time, attention and commitment".*

This reflects that Mozilla is a truly free and non-proprietary organisation. In order to achieve this, Mozilla tends to follow and implement **the distributed development and centralised integration model**, which is similar to the 'bazaar style', as written by (Raymond, 1999). The bazaar style represents the method of releasing new versions early and frequently, where the code is developed by a large team of developers and testers over the internet in view of the public, thereby offering the public the opportunity to shape the code. In contrast, the cathedral is the typical development style for proprietary software orientation, using small teams, tight management control, and long release intervals. For example, in the Cathedral model, the source code is not normally provided even with releases.

As such, Mozilla complement this model - the distributed development and centralised integration model - by focusing on meritocracy and self-regulation in their operation. For example, Mozilla provides the platform for individuals to submit their code for the development of Firefox. If approved and the code is effective, the person then becomes a committer, which reflects that acceptance of the contribution is based on merit. In addition, Mozilla inspires the community of practices towards self managed, self controlled, self organised processes and decision making where the individual is given more freedom in performing his/her task.

It is fair to say that, all of the above-mentioned represents the current culture at Mozilla, the way it operates and manages the processes and integration within Mozilla communities.

7.2.5 Mozilla Products

There are three product sets in Mozilla namely: (1) Mozilla main product (i.e. Mozilla Firefox, Thunderbird and Fennec), (2) Mozilla-based applications (applications that are built by individuals and organisations using Mozilla technologies, i.e. Boxee and Scenari), and (3) Third party applications (applications that are built by third parties that are embedded with in a Mozilla product, i.e. Add-ons site). **Table 7.2** below provides some descriptions of Mozilla products and their significance to the company.

Table 7.2: Mozilla key and supporting products

Product	**Description**	**Significance to the company**
Firefox	Firefox is a web browser, which provide security and fully customisable to use online; features that make online experience even better with the new release of Firefox® 3.6.	Key product and consider as the most mature Mozilla product.
Thunderbird	Thunderbird™ is Mozilla's e-mail client. Thunderbird able to make emailing safer, faster and easier and can be scaled to meet the most sophisticated organisational needs.	Key product
Fennec	Fennec is the first Mozilla browser optimised for mobile platforms. Fennec is the code name of the effort in building a browser for mobile phones and smaller non-PC devices.	Key product but still in developing phase.
Lightning and Sunbird	Lightning is a calendaring, scheduling and task management extension. Sunbird® is a cross-platform application that brings Mozilla-style ease-of-use to users' calendar.	Supporting product

Bugzilla	Bugzilla™ is a bug tracking system designed to help teams manage software development. Organisations across the globe can use this tool to be organised and communicate effectively.	Supporting product
Camino	Camino® is a Web browser optimised for Mac OS X with a Cocoa user interface, and Gecko layout engine. It is the simple, secure, and fast browser for Mac OS X.	Supporting product
Sea Monkey	SeaMonkey® is the all-in-one application formerly known as the "Mozilla Application Suite", containing a web browser, a mail and newsgroups client, an HTML editor, web development tools, and an IRC chat client.	Supporting product

As mentioned earlier, the Mozilla Firefox Web browser is Mozilla’s key/premier product. In fact, Firefox can be considered Mozilla’s most mature and successful product. An overview of Firefox is summarised by (Bailey & Back, 2006, pp. 291-292) in the following quotation:

“Firefox is a web browser that is being developed as part of the Mozilla suite of open source software. Firefox extensions are small applications that add new functionality to the core browser. Firefox is unique in how it supports such third-party extensions. Firefox’s designers acknowledged that they could not foresee all possible design choices within a browser and did not want to impose their choices on others. Unlike more traditional browsers, which support extensibility only through a set of well-defined interfaces to existing components, Firefox puts the core browser code and the extension code on equal footing. This design enables developers to build a custom browser for a particular group of users, with features that reflect the needs of those users. The resulting application blends core components and extensions in a seamless fashion. Consequently, users do not have to learn a new user interface when using extensions. Firefox also supports the creation of multiple profiles, allowing the user to maintain different combinations of extensions for different purposes. Extensions execute with the same privileges as the user running the browser. The user is asked to confirm during the installation that they trust the extension developer, because extensions have full access to the same information to which the user has access on the internet. Although the way in which Firefox provides extensibility is novel, the extensions themselves leverage established

technology, which makes their development relatively easy to learn. An extension is a combination of XUL, JavaScript, and associated resources such as localization information, images, and other media files. XML User-Interface Language (XUL) is an XML-based language that allows developers to specify the extension's user interface".

In addition, several authors such as, Brown (2007) highlight that the benefit of Firefox resides in its capability to program the activities of the browser and react to the HTML that is being displayed. An example, Greasemonkey (a Firefox scripting add-on), can make changes to HTML received from particular websites, by adding or removing content, or interfacing with that content in some way. Further, Firefox works equally well as a stand-alone web browser and still-image viewer (i.e. GNOME or KDE[15]), and is also supported through properly configured plugins, the viewing of in-line streaming audio or video, PDF and DjVu documents, Java-based programs, and Adobe Flash animations (Delozier, 2009). In addition, Firefox can treat the feeds as live bookmarks**,** so that links are updated to previously identified web pages automatically (Myhill, Shoebridge, & Snook, 2009).

7.2.6 Mozilla Firefox Market and its Rivals

In order to further understand the Mozilla Firefox, it is also necessary to discuss on how Firefox position itself in the web browser market and in relation to its competitors. Following on from this, this section provides a description of the Firefox market and its rivals. Over the years, Firefox has rapidly progressed and steadily assumed Microsoft Internet Explorer's commanding share of the market. When Firefox was launched in late 2004, approximately 95% of the world's web surfers were using Microsoft's Internet Explorer (IE). Back in May 2004, Firefox's worldwide market share was 18.4%, while Internet Explorer's stood at 73.8%, with Apple's Safari browser accounting for most of the rest (Hamm, 2008).

NetApplications and StatCounter, which provide usage indicators for the web browser (Anonymous, 2009b, 2009f; MacMillan, 2009a). To a certain extent, this

[15] GNU Network Object Model Environment (GNOME) and Kernel Density Estimation (KDE) are the open source software development. See http://www.gnome.org/ and http://www.kde.org/ for further details.

shows the general acceptance and reliability of these internet metrics providers. For that reason, the researcher also opts to use NetApplications and StatCounter, in order to further understand the Mozilla Firefox market. For example in August 2009, according to NetApplications, Microsoft Internet Explorer's global market share was 66.97%, while Firefox had a global market share of 22.98%. This was followed by Apple's Safari's market share, which was 4.07%. Opera had a 2.04% market share, and Google Chrome reached 2.84% (Anonymous, 2009b). This reflects that, at present, Mozilla Firefox is the second most popular browser on the market, as most studies demonstrate that Firefox has already gained more than 20% of the world market share (Anonymous, 2008b; Taylor, 2009; Wang, et al., 2007).

The numbers provided by StatCounter, another Internet metrics firm, tell a similar story, revealing that Internet Explorer slipped from 58.37% in September 2009 to 57.96% in October 2009, and then to 56.27% on the first day of November 2009. The StatCounter's measurements suggest that Internet Explorer could become the number two browser next year, if Internet Explorer's approximately 10 percent global market share loss – recorded between October 2008 and October 2009 - continues to decline at approximately the same rate, as cited from (Anonymous, 2009d). Further, based on (Anonymous, 2009d) claims that, "*If Internet Explorer's life story were to be a movie, it might be titled, The Browser that Fell to Earth."* **Figure 7.1** illustrates the web browser market share comparison according to StatCounter as at December 1, 2009.

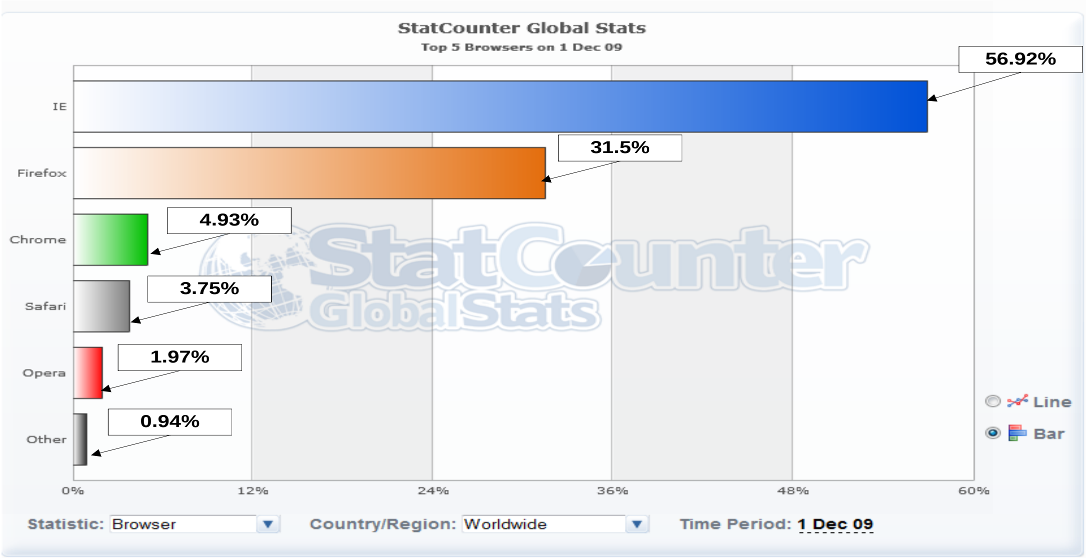

Figure 7.1: Tabulated market share worldwide for web browser.

Source: StatCounter Global Stats at http://gs.statcounter.com/#browser-ww-daily-20091201-20091201-bar

In comparison to Mozilla Firefox's rival, Google Chrome, it is notable that six months after Firefox launched in November 2004, they had achieved a global market share of over 8%. Six months after its launch, in September 2008, Google Chrome had a global market share of just over 1%. Though the two browsers were not released under the same circumstances, it is clear that Firefox gained a greater market share compared to its competitor during the introductory phase (Anonymous, 2009a) based on NetApplications. As such, Firefox's one billion downloads have about 300 million active users, which earn Firefox about 30% of the global browser market, according to StatCounter, cited from (Anonymous, 2009a).

In addition, Mozilla is also branching out into other markets. The company expects to deliver a version of Firefox for mobile phones before the end of 2009. Clearly, one of the reasons Mozilla was able to be successful on the desktop is that it afforded users the ability to create and install extensions for a range of purposes, such as blocking advertisements or playing music. Mozilla is bringing this element to Fennec (Mozilla browser for mobile), and it is said that the developer community is beginning to create some "exciting" add-ons like GeoGuide's location-aware mapping, and GraffiTwit's Twitter client, as these should be relatively easy for developers to port existing extensions to the mobile browser (Anonymous, 2009c).

7.2.7 Mozilla Achievement/Success Stories

Mozilla is built upon the view of the power of people working together collectively, also known as communities of practice or virtual communities. For example, Mozilla claims "*Firefox 3.5 was built through Mozilla's global, open source development process. The Mozilla community comprises thousands of passionate contributors, including experienced developers, security experts, localization and support communities in more than 60 countries, and tens of thousands of active testers. With more than 300 million active users, Firefox is the only popular Web browser created by a non-profit organization. Firefox 3.5 makes surfing the Web easier and more enjoyable with exciting new features and platform updates that allow Web developers to create the next generation of Web content. Native support for open video and audio, private browsing, and support for the newest Web technologies will enable richer, more interactive online experiences"* (Anonymous, 2009e).

Other companies would like to follow the example of Mozilla, which relies on contributors who work for no pay. *"There's no easy way to copy Mozilla,"* says Clay Shirky, author of Here Comes Everybody: The Power of Organising without Organisations. *"But I do think that companies are increasingly going to look for ways to motivate their users to be participants"* (MacMillan, 2009b).

The Mozilla model holds lessons for a broad range of companies. "*The profit motive wouldn't matter if the company is committed to fostering community and openness,"* says Kevin Gerich, a Web Development Manager at the International Data Group, who has contributed to Mozilla on and off since 2002 (MacMillan, 2009b). It is fair to say that most of the developers who add value to Firefox by creating add-ons without having any real expectations of being paid, are motivated by sharing, gaining personal self-satisfaction and continuous learning.

In addition, the success of Mozilla can be seen through the recognition of Firefox and Thunderbird. Examples of such awards and recognition to Mozilla are illustrated in **Table 7.3** and **7.4** below:

Table 7.3: Mozilla's Firefox Awards

Year	Awarded From	Descriptions
2005	PC-Welt Readers Choice Award	Best Internet Tool
2005	PC-Welt Editorial Staff Award	Titan of the Year for best Open Source project
May 2005	Forbes	Forbes Best of the Web
June 2005	PC World	PC World Product of the Year
November 2005	UK Usability Professionals' Association Award	UK Usability Professionals' Association Award Best Software Application 2005
June 2006	Lutèce d'or Award	Lutèce d'or for best OpenSource project, Paris
July 2006	PC World's	PC World's 100 Best Products of 2006
September 2006	Digital Lifestyle Award	Digital Lifestyle Award, Berlin
October 2006	CNET Editors' Choice Award	CNET Editors' Choice
December 2007	PC Pro Award	PC Pro "Software of the Year" Award 2007
December 2007	.Net Award	.Net Award for Open Source Application of the Year

Source: http://www.mozilla-europe.org/en/pressroom/awards/

Table 7.4: Mozilla's Thunderbird Awards

Year	Awarded From	Descriptions
June 2005	PC World	PC World, Top 100 Best Product, 2005
September 2005	TUX Readers' Choice Award	TUX 2005 Readers' Choice Award
May 2008	Linux Journal Readers' Choice	Linux Journal Readers' Choice 2008 - Favorite E-mail Client
May 2008	May 2008	PC World Best 100 Products of 2008

Source: http://www.mozilla-europe.org/en/pressroom/awards/

7.3 Thematic analysis of quality and technology management in Mozilla

As mentioned in **Chapter 5**, there are four common principles in quality and technology management, which merit further analysis, namely, continuous improvement, standards, leadership and supplier relationships/partnerships. Therefore, this section focuses on an analysis of the case study according to the four themes.

7.3.1 Continuous Improvement

Improvement to Mozilla's operations first came from Bugzilla, the bug-tracking system designed to detect problems in the source code. Following on from this in 1999, Quality Assurance was introduced with the aim of providing opportunities to people, who might not be coders, to test and submit bug reports. Slowly and gradually, Mozilla has improved its quality through Bugzilla, which is able to track dependencies between bugs. It is fair to say that in the early releases of Mozilla, improvements were focused on Mozilla features such as convenience, flexible searches, fast installations and updates. The emphasis of improvement is now on building a new technological platform (i.e creating new technology) and continually improving the existing product (i.e. fixing bugs). This can be seen by following releases in the Mozilla series; i.e. Mozilla 0.6 back in 2000 to Mozilla Thunderbird 3.1 (the e-mail client) and Mozilla Firefox 3.6 (web browser) today.

In 2004, Mozilla promoted the quality program **Security Bug Bounty Program** to encourage the identification and reporting of security issues. $500 cash prize was awarded to users who identified and reported security vulnerability in the open source projects. It could be argued that the turning point in Mozilla's continuous improvement program was the release of Mozilla Firefox in the same year. This was considered to be the Second Generation of Mozilla, which focused on providing **more value** in their products for users. Wusterman (2005) claims that as of early December 2004, there were 58 Firefox 1.0 themes available for download, and the use of a different theme not only changed the colour scheme of Firefox, but could also change the browser's entire appearance. Additionally, the improvement has now shifted from fixing and rectifying problems of security issues and improved stability to providing more value to their users. This is supported by the launch of a new Firefox Add-ons website in 2007**.** This Firefox Add-ons website makes it even easier for Firefox users to find and install thousands of free extensions and themes for a totally customised browsing experience.

Following on from this, Mozilla made a similar impression by releasing Firefox 3 in the middle of June, 2008. According to the Mozilla Foundation, it set a new Guinness World Record with 8,002,530 downloads within the first 24 hours (Anonymous, 2008c; Pereira, 2009).

Table 7.5 as follows provide some of the Mozilla improvement through Firefox 3.0.

Table 7.5: Mozilla Firefox 3.0 Improvement

Features	Descriptions
Duplicate tabs with drag-and-drop	Simply hold the Ctrl key while dragging the tab to duplicate to an empty space on the tab bar.
Minimize the toolbar	Choose Customise, and select Use Small Icons and the new controls are perfectly functional but smaller, allowing the toolbar to shrink and leaving more room for viewing sites.
Use smart bookmarks	Smart bookmarks are live bookmarks that actually generate live lists of sites according to parameters user define.
Send e-mail via Yahoo Mail or Gmail by default	Clicking on an e-mail address on a Web page will open up a new e-mail using user default e-mail program.
Add-Ons manager	Allows viewers to see a list of popular Add-Ons without redirecting the browser to a third party web page, as users can install the recommended Add-Ons directly.
Security Control	Integrating new security-related tools through anti-phishing protection.

Source: http://www.mozilla-europe.org/en/press/2008/06/17/1171-mozilla-releases-firefox-3-and-redefines-the-web-experience;(Anonymous, 2008c).

Mozilla updated this in 2008 with the release of Mozilla Fashion Your Firefox, a new application that enabled Firefox users to customise their browser based on their interests and online activities. This web application introduced easy discovery and installation for add-ons. *"One of the best parts about Firefox is the amazing richness of our 5,000-plus free add-ons. We're excited to introduce Fashion Your Firefox because it makes it even easier for people to discover useful add-ons that make the browsing experience better and more personal"* said Mike Shaver, Vice President of Engineering at Mozilla (Anonymous, 2008a). Further description is illustrated in **Table 7.6**.

Table 7.6: Categories in Fashion Your Firefox

Categories	Descriptions
Shutterbug	View and share pictures and videos online
Rock Star	Listen to music while surfing, working, emailing or researching online
News Junkie	Get the most up-to-date news and weather
Shopaholic	Shop and take advantage of online deals
Digital Pack Rat	Keep track of favorite sites, bookmarks and blogs
Social Butterfly	Share, bookmark, and e-mail web pages via an array of social networking & bookmarking sites
Finder and Seeker	Find and make information on the Web more relevant
Decorator	Apply browser themes
Executive Assistant	Organise online activities

Source: http://www.mozilla.com/en-US/press/mozilla-2008-11-18.html; (Anonymous, 2008a).

Following on from that, the most Mozilla improvements come through Firefox 3.5 with features including private browsing, geolocation, and support for the latest audio, video, graphics, and HTML 5 (Anonymous, 2009g). **Table 7.7** below provides some improvement of Firefox 3.5.

Table 7.7: Mozilla Firefox 3.5 Improvement

Features	Descriptions
Geolocation	By clicking on the Show My Location icon, Firefox will attempt to determine users' location and with users' permission, Firefox lets Google Maps know where the users are.
Performance Improvements	Firefox 3.5 using a new JavaScript engine called TraceMonkey. Firefox 3.5 handles crash management better than previous versions. Previously, when Firefox crashed and re-started it, it asked whether user wanted to re-open the tabs and windows from the previous session. Now, it asks the user which tabs and windows they want to open, so this can exclude a misbehaving web page to keep the browser from crashing again.
Private Browsing	When users switch to private browsing, Firefox shuts down all existing browser windows and tabs, leaving only the private browser window open, as other browsers leave existing windows and tabs open and open a new window for private browsing.
Forget this Site	Removing every trace of a site from browser.

Source: http://www.mozilla.com/en-US/press/mozilla-2009-06-30.html; (Anonymous, 2009g).

Overall, Firefox 3.5 lives up to Mozilla's claims that it is about twice as fast as its previous release and considerably faster than the market leading Internet Explorer 8. In Geolocation, Firefox uses the W3C Geolocation API to determine user location by looking around for nearby Wi-Fi access points and consulting a database of known Wi-Fi locations around the world; if that does not work, it looks up the user IP address and finds the location using that information. Geolocation is a convenience, as the user is free from having to type their address repeatedly when they are at home or in an office, and even more helpful when away, or at an hotel where the user does not know their address (Anonymous, 2009g). Firefox 3.5 can also tell websites where the user is located, so the user can find information that is more relevant and more useful; for example, in getting directions or finding a nearby restaurant. Another important improvement built into Firefox 3.5 is support for the latest web technology standards, including next-generation graphics and open video and audio formats that allow modern web pages to display rich media without requiring a plug-in or a proprietary software download (Taylor, 2009). Perhaps the best improvement of all is that Firefox 3.5 can draw on a growing library of more than 6,000 add-ons, ranging from bookmark and online auction to weather applications and digital image uploaders which are all accessible from within the browser itself.

The most recent improvement to Mozilla Firefox comes through Firefox 3.6, which was officially released on January 21, 2010. Mozilla claims that Firefox 3.6 is more than 20% faster than its previous release and is more stable and secure, as a result of changes in the way that third party plug-ins work and are updated[16]. With Version 3.6, Firefox now tracks plug-ins, and users can view the web page to see if their plug-ins are up-to-date or need to be upgraded. In addition, the latest version also features support for new web technologies, including HTML5 elements such as video tag. The video tag allows web browsers to play online videos without using proprietary video technology like Flash (Anonymous, 2010b).

As such, Firefox 3.6 is more customisable, as a result of new user-selectable themes called Personas. Personas allow users to apply a custom visual display to the user interface elements, such as toolbars, menus, tabs and status bars. With this latest release, users are able to make changes to the whole look of their browser[17].

Overall, the summary of the improvements to Firefox 3.6 over Firefox 3.5 is illustrated in the **Table 7.8** as follows:

[16] Description of Mozilla Firefox 3.6 Version is available at http://www.mozilla.com/en-GB/firefox/3.6/whatsnew/ and http://www.mozilla-europe.org/en/firefox/3.6/releasenotes/.
[17] See Personas at http://www.getpersonas.com/en-US/

Table 7.8: Mozilla Firefox 3.6 Improvement

Features	Descriptions
Open video and audio	Via an implementation of HTML 5 audio and video; video can be displayed full-screen, and poster frames are supported
Personas	Personalise the look of Firefox
Plug-in updater	Offering protection against vulnerabilities; out-of-date plug-ins will be detected
Stability improvements	Decrease crashes caused by third-party software
Performance	Improved JavaScript performance, overall browser responsiveness, and start-up time

Source: http://www.mozilla-europe.org/en/press/2010/01/21/1363-mozilla-delivers-firefox-36-to-millions-of-users; (Krill, 2010)

In terms of the Mozilla projects, the next major Firefox release, Version 4.0 is expected to be released in late 2010 or early 2011. Firefox 4.0 includes a project called Electrolysis, which will launch each tab window under a separate process. This platform will use separate processes to display the browser user interface (UI), web content, and plug-ins[18]. Ideally, this will make Firefox 4.0 even more secure and stable, and may also result in user interface changes (Anonymous, 2010a).

Additionally, another recent improvement to Mozilla comes from the latest version of mobile Firefox, which offers Windows Mobile users better support for touch screens and greater stability (Anonymous, 2009c). Mozilla continues to work on its mobile version of Firefox, and it released two new builds of its Fennec browser for Windows Mobile and Nokia's Maemo devices. The latest versions of the mobile browser use the Gecko HTML rendering engine, and both versions support the TraceMonkey engine for JavaScript support. This latest versions improves the touch-screen support for Windows Mobile devices, as well as polish the overall performance and user interface (Anonymous, 2009c).

In summary, continuous improvement at Mozilla can be seen in the form of: (1) **Ideas.** Ideas of improvement come from community of network, such as Mozilla Zine and Quality Mozilla (QMO) which provide the platform for forums, chat, news and blogs), (2) **Action.** Through Bug Bounty Program, Add-Ons Manager the customised browsing experience and Mozilla Labs the concept series, (3) **End**

[18] Description about Mozilla Firefox 4.0 Version is available at: https://wiki.mozilla.org/Electrolysis and http://www.mozilla.com/en-US/firefox/4.0b3/releasenotes/

product: products improvement. New release of Mozilla product line, such as Mozilla Firefox 3.6 and Mozilla Thunderbird 3.1. The principle of continuous improvement in Mozilla works through open participation which involves technical (i.e. Mozilla coders/developer) and non-technical people both internally and externally (see more details in the following section of the Mozilla code of practice) in activities, such as fixing a Mozilla bug, making a performance improvement in Mozilla code (no matter how small either technically or non-technically), enabling Mozilla-based products to pass standards compliance tests, writing a Mozilla test case, and creating or revising a Mozilla documentation page. This helps change the future of the web and advances the Mozilla goal of promoting choice and innovation on the Internet. In principle, the understanding of Mozilla continuous improvement can be illustrated in **Figure 7.2**.

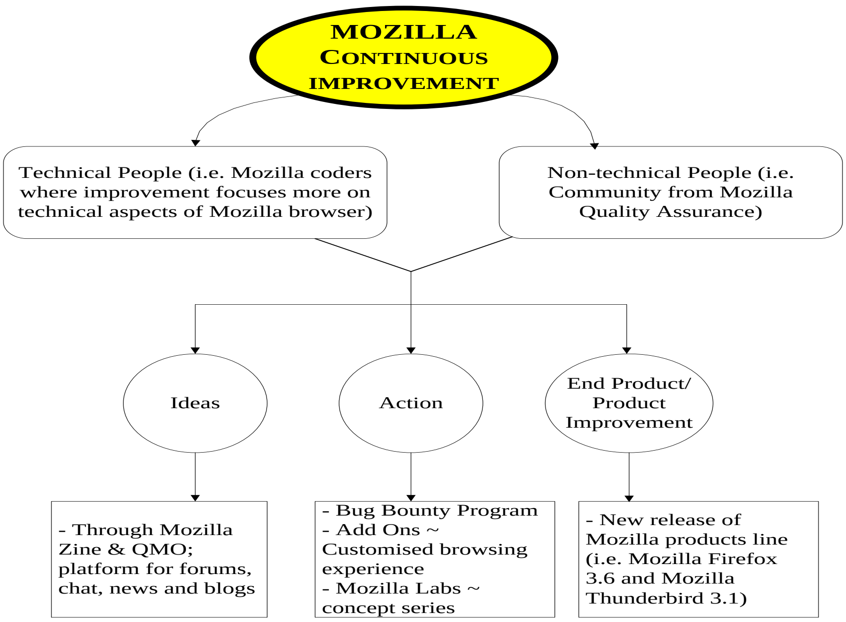

Figure 7.2: Mozilla Continuous Improvement

7.3.2 Standard

In general, Mozilla does not have specific standards or strict rules for doing things, but rather implements various Codes of Practice. This includes the meritocracy concept and follows the Mozilla Manifesto[19] where **Open Standards** are the basis of

[19] Mozilla Manifesto is a Mozilla statement of direction. See further details at: http://www.mozilla.org/foundation/statement-of-direction.html

key technologies. It could be said that Mozilla Open Standards support their ***Free as in Freedom*** ideal, as mentioned in **Section 7.2.4** regarding free culture. This is also demonstrated by the fact that all Mozilla software is an open source and free to any person or companies where individuals can:

- Run the program for any purpose
- Study how the program work and adapt it to their needs
- Redistribute copies at will
- Improve the program and distribute the altered version

In addition, the Mozilla technology standard is based principally on the source code which is open to the public. Therefore, it could be said that, in terms of the technology standard, the standard is open to the public and therefore is a public standard. As mentioned previously, Open Standards are the basis of key technologies at present, and the most striking key technologies in Mozilla are: XPCOM, XUL, Necko and Gecko.

Authors such as Wang, et al., (2007) claim that two key technologies used in the Mozilla are XPCOM and XUL. Wang, et al., (2007) summarise these two key technologies in the following quotation, "*XPCOM provides most of the functionality in Mozilla. Components can be written in C/C++, Python, and JavaScript and are grouped into libraries that handle everything from file system manipulation, to security, XSLT, and rendering. XPCOM components are all cross-platform and new components can be added with a minimum of effort. XUL is used to create GUIs in Mozilla. XUL is HTML-like in its simplicity yet Java Swing-like in its power; it can be combined seamlessly with CSS, SVG, Java applets and can access virtually any XPCOM component via a thin layer of JavaScript. The ease of XUL and the robust, cross-platform nature of XPCOM combines to make Mozilla an ideal framework for rapid application development".* The important of XPCOM is also addresses by Mozilla at https://developer.mozilla.org/en/Gecko_Embedding_Basics.

Additionally, Bailey and Back (2006, p. 292) also state that, "*XUL is Mozilla's powerful, widget-based markup language from which Firefox's user interface is built. It provides elements such as windows, tabs, buttons, text fields, labels, menus, and* *dialogs for the construction of two-dimensional user interfaces. XUL is based on existing standards, including XML, Cascading Style Sheets, Document Object Model (DOM) and JavaScript. Developers familiar with these standards will be immediately productive in XUL. XUL separates the layout and appearance of the user interface from the application definition and logic. Whereas the layout and appearance is specified using hierarchies of XUL elements, the application logic is implemented as JavaScript code. The JavaScript code is associated with these XUL elements in a manner that is similar to how event handlers are associated with DHTML elements in client-side JavaScript code that is part of many web pages. The underlying Gecko rendering engine, upon which Firefox is based, renders the XUL code using the native widgets of the underlying windowing system to create a uniform look-and-feel".*

Necko[20] is a network library that provides a platform-independent API for several layers of networking, ranging from transport to presentation layers. This API is used in many Mozilla-based client applications (including Firefox) and can be used for writing other networking clients. Gecko[21] is the other prominent technology for Mozilla. It is a layout engine of the Firefox web browser. It is designed to support open Internet standards, and is used to display web pages and, in some cases, an application's user interface by rendering XUL. Gecko offers a rich programming API that makes it suitable for a wide variety of roles in Internet-enabled applications, such as web browsers, content presentation, and client/server.

The details of key technologies at Mozilla are summarised in the following **Table 7.9**.

Table 7.9: Mozilla Key Technologies

Technologies	Descriptions
Gecko	Gecko is the layout engine that reads web content, such as HTML, CSS, XUL, and JavaScript and renders it on a user's screen. In XUL-based applications, Gecko is used to render the application's user interface as well.
Necko	Necko is a network library that provides a platform-independent API for several layers of networking, ranging from transport to presentation layers. This API is used in many

[20] Description about Necko is available at https://developer.mozilla.org/en/Necko
[21] Description about Gecko is available at https://developer.mozilla.org/en/Gecko_Embedding_Basics

	Mozilla-based client applications (including Firefox) and can be used for writing other networking clients.
Tamarin	Tamarin is a JavaScript engine written in C++. It currently implements Adobe ActionScript® 3 (a superset of ECMAScript Edition 3) and is embedded within the Adobe® Flash® Player 9.
SpiderMonkey	SpiderMonkey is Gecko's JavaScript engine written in C. It is written to be embedded easily and can be found in a variety of different applications including Firefox.
XPCOM	XPCOM is a cross platform component object model, similar to Microsoft COM. It has multiple language bindings, letting the XPCOM components be used and implemented in JavaScript, Java, and Python in addition to C++.
XULRunner	XULRunner provides an environment for developers to build XUL-based applications such as Firefox and Thunderbird. It provides mechanisms for installing, upgrading, and uninstalling applications.
Netscape Portable Runtime	Netscape Portable Runtime (NSPR) provides a platform-neutral API for system level and libc-like functions. The API is used in the Mozilla clients, many of Red Hat's and Sun's server applications, and other software offerings.
Network Security Services	Network Security Services (NSS) is a set of libraries designed to support the cross-platform development of security-enabled client and server applications. Applications built with NSS can support SSL v2 and v3, TLS, PKCS #5, S/MIME, X.509 v3 certificates, and other security standards.
Rhino	Rhino is an open-source implementation of JavaScript written entirely in Java. It is typically embedded into Java applications to provide scripting to end users.

Source: http://www.mozilla.org/projects/technologies.html

As mentioned earlier, the way that Mozilla run their operations is based on the mutual understanding of the codes of practice, which means that there is no formal or rigid standard being used on a daily basis. Mozilla's code of practice requires a module owner and peer review before the code is checked into the Mozilla system. Checking into most of the Mozilla tree also requires an additional level of pre-check-in code review. This review is completed by one or more of a designated group of strong hackers, known as reviewers. This level of review has become known as a "super-review". The explanations of Mozilla practices are as below:

- **Module Owners and Peers**

  A module owner is the person to whom leadership of a module's development has been delegated. A code module is a collection of source files that form a coherent bundle, and a peer is a person whom the owner has designated to help maintain the module. If a module has an owner, the owner or peer should in general review all code changes that go into that module[22]. The module owners must conform to a set of criteria in order to keep the position. These criteria or standard behaviour/skills are:

- ✓ Expertise with the code in the module
- ✓ Current level of involvement with the module
- ✓ Understanding/vision of where the module ought to be headed
- ✓ Appropriate understanding of Mozilla codebase as a whole and the module's relationship to it
- ✓ Ability to evaluate code for that module, including contributions of patches and new features
- ✓ Ability to evaluate impact of code on other parts of the codebase
- ✓ Ability to communicate with a diverse, geographically distributed community
- ✓ Willingness to evaluate contributions on their merits, regardless of their source
- ✓ Ability to consider varying perspectives and needs of different consumers of that module
- ✓ Ability to resolve different needs through factoring or other abstraction techniques when appropriate

- **Release Drivers**

Drivers provide project management for milestone releases. The drivers provide guidance to developers as to which bug solutions are important for a given release and make a range of tree management decisions. The drivers are particularly active after the trunk (the set of activity) is frozen for a milestone release, and in managing the milestone branch until a milestone is released. During this time, the Drivers watch the checkins very closely, and generally require that every patch is reviewed before it is checked in.

[22] The details of Mozilla module owners and peer is available at: http://www.mozilla.org/about/owners.html

- **Super- Reviewers**

Super-reviewers are a designated group of strong hackers who review code for its effects on the overall state of the tree and adherence to Mozilla coding guidelines. A super-review generally follows a code review by the module owner, and the approval of a super-reviewer is generally required to check a code.

- **Bugzilla Component Owners**

Component owners are expected to review bug reports regularly, reassign bugs to correct owners, ensure test cases exist, track the progress toward resolving important fixes, and otherwise manage the bugs in the component.

As well as these participants, Mozilla uses an access-controlled database known as *"Despot"* (despot.mozilla.org) to track code modules, module owners and peers[23]. Although Mozilla does not have a specific standard in running their daily practices, Mozilla codes of practice determine the right things to do, specifically to improve code quality. An example of this took place in 2000 when Mozilla implemented 'Check-in Rules' which required that all changes had to be approved by a designated Mozilla code reviewer.

Further, in 2001, Mozilla announced plans to re-license Mozilla to make it more General Public License (GPL) compatible. More than 6000 Network Public License (NPL)/Mozilla Public License (MPL) - (dual license) files are being re-licensed under MPL/GNU; GPL/GNU and a Lesser General Public License (LGPL) tri-licence. LGPL provisions do not address all the possible ways in which codes released under the MPL and codes released under the LGPL could be combined to form a larger work. The Mozilla Public License sets out the terms under which the Mozilla code may be used. The MPL has been approved by the **Open Source Initiative** as an Open Source license.

It is becoming clear that Mozilla's efforts are towards the public standard, as it is based on triple license[24]: Mozilla Public License (MPL), GNU General Public

[23] Description about Despot can be found at http://www.mozilla.org/hacking/module-ownership.html
[24] Description about Mozilla triple licenses can be found at http://www.mozilla.org/MPL/relicensing-faq.html

License (GPL) and GNU Lesser General Public License (LGPL). As such, the Mozilla code has always been released under some form of copyleft licensing to promote the sharing of modifications to the Mozilla code, and this was one of the motivations behind the original creation of the NPL and MPL.

The only formal standard that Mozilla complies with is a Web Standard called **Acid**. Acid1 is a test page for browsers, which was developed in October 1998 and was important in establishing baseline interoperability between early web browsers. Ideally, Acid1 tests were designed to produce a clear indication of a browser's compliance to web standards[25]. This followed with Acid2 initiated by the World Wide Web Consortium and Internet Engineering Task Force specifications. The idea is that if both websites and web browsers follow agreed industry standards, then any website will work the same in any web browser. On October 31, 2005, Safari 2.0.2 became the first browser to pass the test. Opera, Konqueror and **Mozilla Firefox** followed[26].

In summary, Mozilla does not have a rigid standard (i.e. ISO series), but it operates according to these three main elements namely; (i) Open technology standards, (ii) Codes of practice and (iii) Standards of control. **Figure 7.3** as follows illustrates the standards at Mozilla. These three elements are linked and interrelated and shape the standard performance at Mozilla.

[25] Description about Acid1 can be found at http://en.wikipedia.org/wiki/Acid1
[26] Description about Acid2 can be found at http://en.wikipedia.org/wiki/Acid2

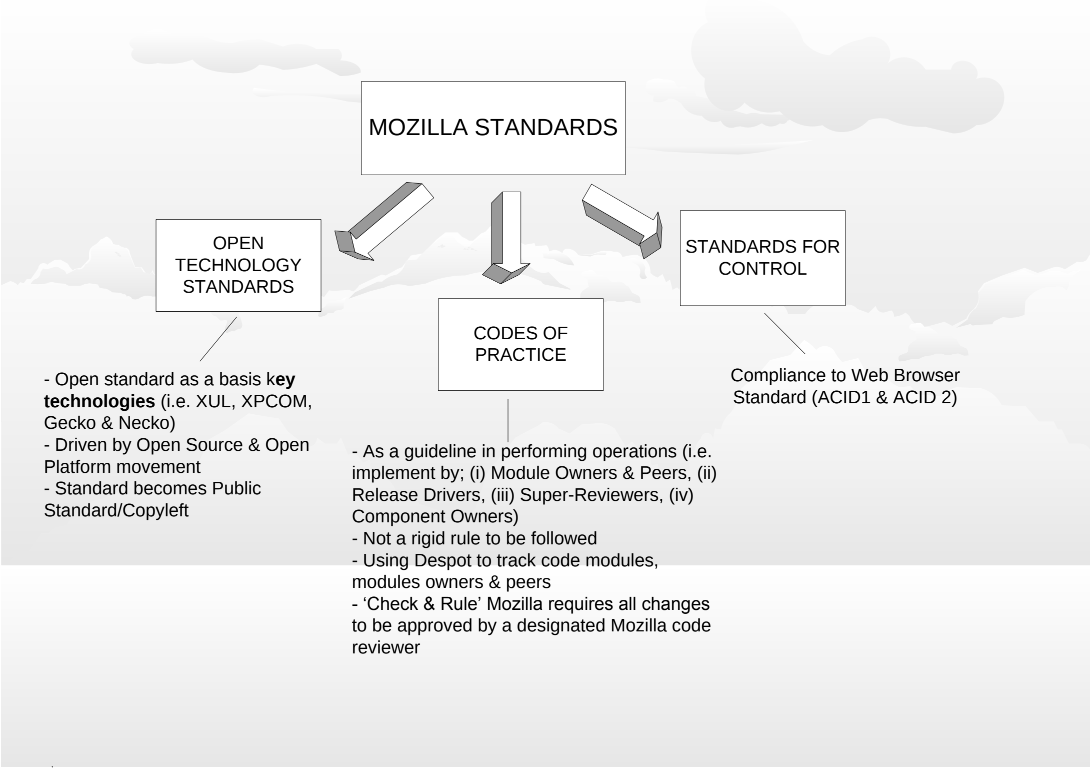

Figure 7.3: Standards in Mozilla

7.3.3 Leadership and direction of Mozilla

The Mozilla organisation is the entity which coordinates Mozilla development. The mission of Mozilla is to foster a successful open-source project[27]. Mozilla provides a wide range of services to assist the Mozilla development community. It provides technical and architectural direction for the Mozilla project, working with contributors to make the Mozilla code useful in a wide variety of products, platforms and devices. As such, it develops and implements processes to enhance public discussion, distributed development, and peer review.

In general, Mozilla operates in the 'Bazaar Style' (as previously discussed in **Section 7.2.4**) and tends to follow the model of distributed development and centralised integration. In making decisions, Mozilla uses the following guidelines:

"Decisions ought be proposed and discussed in public forums, and the resolution communicated in those forums".

[27] Direction of Mozilla project can be found at http://www.mozilla.org/editorials/mozilla-overview.html

“Consensus should be sought, but unanimity is not required; few important decisions will be unanimous”.

“Alternatives that avoid head-on confrontation between contributors ought to be explored very carefully and adopted where appropriate”.

“Goals limited to a particular contributor should be implemented in that particular contributor's world”.

“Decisions must be based on what we believe is best for the entire community, not based on the desires of any one contributor”.

Source: http://www-archive.mozilla.org/editorials/mozilla-overview.html

It is clear that the success of Mozilla is based on inspiring and excellent leadership. Some of the quotations from Mitchell Baker, the Mozilla Chair are as follows:

“What makes internet healthy and what makes internet life good is participation. People can get involved when they don’t have to, but you can when you want to[28]”.

“We live and die as a community…the real driver of the accountability is the sat of people that involved[29]”.

The Mozilla leadership drove Mozilla into the web browser market, as they already foresaw the internet landscape changing in the browsing space. Whoever controls the web browser has the advantage of controlling the internet, as users need to use the web browser in order to launch other websites. To a certain extent, a web browser becomes more powerful when it is able to perform the functions which had previously been carried out by a desktop. For example, more functions are now embedded within the web browser, including the ability to be stored in the cloud; servers that run the internet, which means a new software program can be used without needing to install it on a hard drive (Mossberg, 2009).

Mitchell Baker claims that, *"We'll continue to be radical about building fundamental qualities such as openness, participation, opportunity, choice, and innovation into*

[28] The Interview with Mitchell Baker Part 1, July 11 2007 at: http://www.youtube.com/watch?v=v2tEPtDTnIo&NR=1

[29] The interview with Mitchell Baker Part 4, July 11 2007 at: http://www.youtube.com/watch?v=sj8ienqMmpE&NR=1

the basic infrastructure of the Internet itself[30]*"*. Further, she wrote in her blog, *"The Internet remains an immense engine of social, civic and economic value. The potential is enormous. There is still an enormous amount to be done to build openness, participation and individual opportunity into the developing structure of the Internet*[31]*".*

In addition to these, Mozilla's leadership also comes externally from the network (i.e. leadership via communities of practice). The intension of Mozilla is to work as a society and tap into the needs and wants of societies, which is evident by their use of the distributed development model (i.e. encouraging individuals to make many of their own decisions on what they do) by offering more opportunities for people in the network to participate and collaborate, as well as providing a greater range of choices, and the freedom to think and work in a more innovative way.

As such, the principles of leadership in Mozilla network operate on the following basis:

➷***Operate as a meritocracy*** *and as a* ***self-regulating system***

As mentioned earlier, in the Mozilla culture, meritocracy and self-regulation are the core driving factors that have become a part of the Mozilla culture. These two factors are illustrated in the following quotations:-

"…so the more good code you contribute, the more you will be allowed to contribute: that is, the better a developer you prove yourself to be through your actions, the more responsibility you will be given. This is not a Consortium. There is no such thing as membership. If you contribute code, then you're a member. It's as simple as that."

"…if a module owner is viewed by the public as not doing a good job (perhaps their releases tend to be buggy, or non-portable; or perhaps they aren't responsive to bug fixes or suggestions) then what will happen is, someone out on the net will say to

[30] Mitchell Baker statement in celebrating 10 years of Mozilla can be found at http://www-archive.mozilla.org/mozilla-ten-year.html

[31] Mitchell Baker vision of Mozilla can be found at http://blog.lizardwrangler.com/

themselves (and to us), hey, I can do a better job than that. And we will say to them, go right ahead[32]."

The Emerging Leadership through ***community leadership roles***

Leadership roles are granted based on how active an individual is within the community as well as the quality and nature of his or her contributions. As mentioned earlier in a previous section, there are four different community leadership roles: (1) Module Owners and Peers, (2) Release Drivers, (3) Super-Reviewers and (4) Bugzilla Component Owners. For example, module ownership includes a range of responsibilities aimed at improving code quality, such as:

- ✓ implementing revisions and innovations as appropriate
- ✓ coordinating development with that of the rest of the code base
- ✓ developing and maintaining a shared understanding of where the module is headed
- ✓ developing APIs where appropriate
- ✓ documenting as much as possible
- ✓ responding appropriately to code contributions, design suggestions and the stated needs of the community
- ✓ creating an environment where competent newcomers are welcomed and included

Principle of understanding

Leadership in Mozilla acts on the principle of common understanding. As noted by Raymond (1999), *"the key idea is that in order to build a development community, need to attract people, interest them in what you're doing, and keep them happy about the amount of work they're doing. On top of that the highlight is on appreciating the difference between acting on the principle of command and discipline, as people (the leader), who start from individual vision and brilliance, then amplify it through the effective construction of voluntary communities of interest[33]".*

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[32] Description of the way Mozilla operates as self-regulating system can be found at http://www-archive.mozilla.org/mission.html

[33] See also White Paper: The Cathedral and Bazaar. Eric S. Raymond at: http://www.catb.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/

This suggests that leadership at Mozilla occurs internally and externally, which can be separated into two main elements namely; (i) Facilitative leadership and (ii) Community leadership. The facilitative leadership refers to a style of partnership, where the leader facilitates and pulls ideas and actions together. This can be seen as an umbrella leadership that drives leaders at all levels. Community leadership refers to the type of leadership that emerges from the community, as the leadership roles are granted based on how active an individual is within the community.

In conjunction with this, Mozilla addresses **Mozilla Manifesto (statement of direction)** which remarks that an open Internet is one where:

- People can participate at all levels, with low barriers and without the need to "buy into" a centralized agenda, data source, hardware or software system.
- Open standards are the basis of key technologies.
- Open source software is available for key Internet activities.
- Open alternatives for key Internet activities are competitive with closed, proprietary offerings and desktop-centric offerings.
- People can make and implement decisions about their online experience and their data.

Figure 7.4 as follows, summarises the leadership at Mozilla.

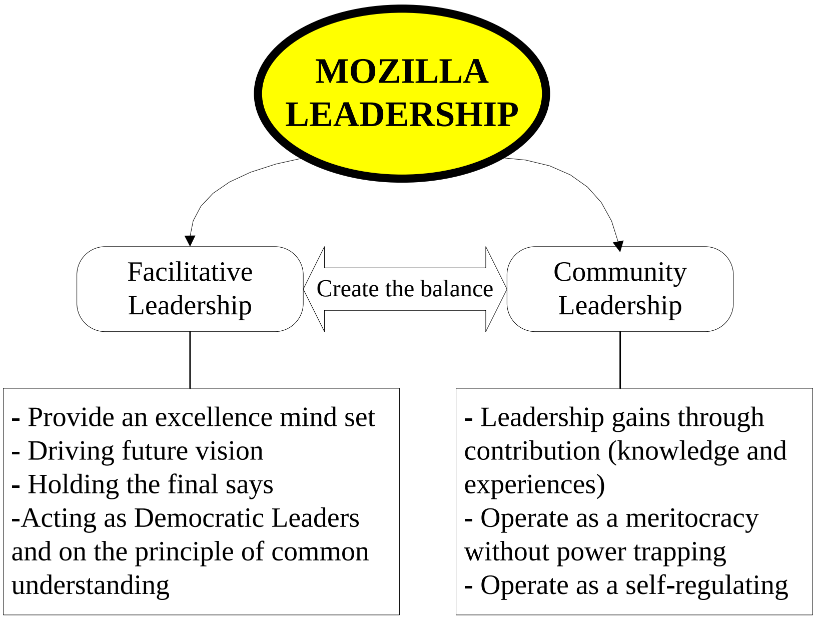


Figure 7.4: Mozilla Leadership

These two types of leadership are interrelated linked to each other, and consequently create the balance of leaderships (i.e. mitigating power struggle) at Mozilla. It is clear that Mozilla leadership uses distributed development where the facilitative leadership, such as the Mozilla Board of Directors and Management Teams, provide inspiration and excellent leadership, and distribute ideas or frameworks so that people within the network can make more decisions and choices, thereby allowing greater creativity, participation and innovation. At this stage, the community leadership roles emerged, as the leadership roles are granted based on how active an individual is within the community as well as the quality and nature of his or her contributions. The decisions on ideas and actions are then centralised, integrated and finalised, as this creates the correct balance of leadership throughout the various processes. The discussion above suggests that the leadership in Mozilla is fluid and organic – one in which leaders can emerge from within the organisational structure and not only through being formally appointed.

7.3.4 Supplier Relationships/Partnerships

Supplier relationships/partnerships in Mozilla happen mainly through Mozilla based-applications (applications that are built by individuals and organisations using Mozilla technologies) and from third party applications (applications built by third parties that are embedded within a Mozilla product. Examples of such relationships can be seen in **Table 7.10** below:

Table 7.10: Mozilla's relationships

Year	Partnering company	Partnering Form
June 2001	Netscape	Netscape 6.1 Preview Release 1, a commercial browser based on Mozilla 0.9.1
August 2002	Oeone	Oeone released the source for its new Home Based Desktop product, an operating environment for Linux, based on Mozilla technologies
August 2002	Netscape	Netscape 7.0 Released which is based on Mozilla 1.0.1
November 2006	Adobe	Adobe and Mozilla Foundation partnership to open source Flash Player Scripting Engine
February 2007	Kodak	Kodak and Mozilla join forces to make sharing photos even easier
March 2007	eBay	Mozilla and eBay working together to make the auction experience easier for Firefox Users in France, Germany and the UK. Mozilla and eBay collaborating to enable eBay users to stay up to date with their auctions from within Firefox regardless of where they are on the web
July 2007	eBay	Mozilla and eBay launch Firefox Companion for eBay Users with free Firefox Add-on in making eBay trading easier, faster and safer
2008	Google	Google extends Mozilla partnership to 2011, as the contract has been renewed for three years
December 2008	Zazzle	Mozilla and Zazzle announce strategic relationship for apparel on-demand. Mozilla dedicated to promoting choice and innovation on the internet, and Zazzle, the leading on-demand retail platform for consumers and major brands, announced a strategic relationship for apparel on-demand. Through the relationship, Zazzle hosts a special Mozilla community store featuring an array of community-generated designs on a variety of apparel for purchase

It is fair to say that the most interesting partnership story is between Mozilla and Google, as this relationship not only functions on a collaborative and complimentary basis, but the two organisations also remain in competition at the same time. The partnership between Mozilla and Google is summarised by (MacMillan, 2009a) in the following quotation; *"Under an agreement between the two, Google's search engine enjoys a default position on the toolbar of Firefox, the second-most-used Web browser after Microsoft's Internet Explorer. To date, the arrangement has proved mutually beneficial. Google accounts for more than 88% of Mozilla's revenue, which totalled $75 million in 2007. And as Mozilla wins over users of Internet Explorer, it helps Google grab share in the lucrative web search market. Firefox has about 22%*

of the browser market, making it by far the strongest competitor to Internet Explorer, which maintains a 67% share, according to Net Applications" (MacMillan, 2009a).

In the sense of competing, this occurred recently when Google launched its own browser, Google Chrome, in September 2008 (MacMillan, 2009a). This reflects their relationship as partners in some network projects and at the same time underlines the fact that they are also competing separately in the web browser market. Authors such as Raphael (2009) claim that the Google Chrome browser may soon let users synchronise bookmarks across multiple computers, as the new bookmark-syncing feature will rely on regular Google user accounts for storing and synchronizing browser-based data. The Chrome bookmark synchronising will mirror at least some of the functionality offered by Mozilla Weave, which is a service currently under development that continually synchronises a user's bookmarks, history, and saved passwords across multiple instances of Firefox (Raphael, 2009). While Keizer (2009) further informs that the Sony corporation's recent agreement to preinstall Google Chrome on its Vaio line of PCs marks the start of a renewed push by the search leader to boost its browser business. Accordingly, the Sony agreement is a milestone, because Google was able to convince the PC maker that its browser is a legitimate contender against Microsoft's Internet Explorer, Apple's Safari and Mozilla's Firefox (Keizer, 2009).

As such, the emergence of Google's Chrome browser, which can also be enhanced with add-ons, means that Mozilla is looking to keep its developers happy by providing them with a revenue opportunity. In response to this, Mozilla announced the launch of its Contributions pilot program, which aims to provide the technical tools necessary for add-on developers to request a payment for their software. As part of the program, developers will be provided with an "About the Developer" page, on which they can explain why they deserve to be paid. The Add-Ons Director, Nick Nguyen stress that "*Our aim with this pilot is to help support a growing ecosystem by providing our users with the opportunity to support their favorite add-on developers"* (Anonymous, 2009).

In terms of promoting partnership, Mozilla has developed a range of partnerships with individuals and organisations in the open source community, start-up companies building businesses based on Mozilla technologies, companies whose web-presence is integral to their product and service offerings, and some of the world's leading technology providers (i.e. Google). Mozilla continues to collaborate with new organisations and this can be seen in their partnerships policy, which clearly encourages individuals and organisations to participate. Partners must go through a five-step process to form relationships with Mozilla, as outlined below:

1. Defining proposed customisations
2. Review and approval of proposed customisations
3. Creation of customised distributions
4. Distribution testing and review of marketing collateral (landing pages, etc.)
5. Finalising distribution agreement and release

In summary, the Mozilla partnering program is currently focused on the creation and distribution of customised versions of the Firefox browser, but there are several ways to engage with Mozilla on other types of partnerships, namely:

- Incorporating Mozilla technology into individual product or service offering.
- Incorporating with mobile browser project/mobile team.
- Incorporating with Mozilla Messaging site for matters related to Thunderbird and related messaging products and technologies.
- Partnering opportunities in working with Mozilla through distributing Firefox to promote individual product or service offerings.

Source: http://www.mozilla.com/en-US/about/partnerships.html

Figure 7.5 as follows, illustrates the partnerships at Mozilla.

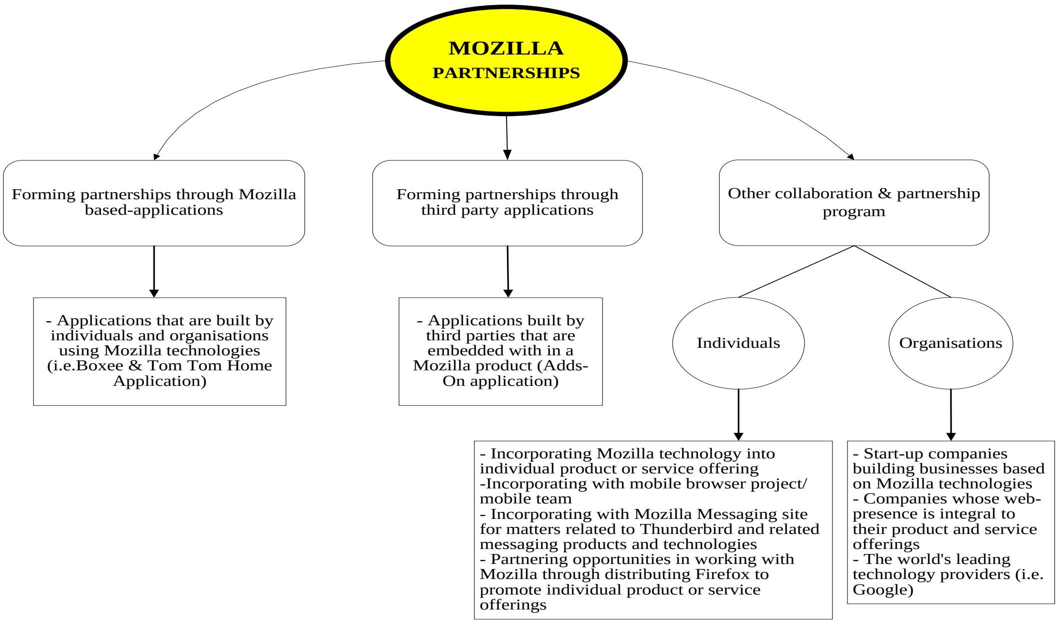


Figure 7.5: Mozilla partnerships

7.4 Conclusion

In conclusion, the researcher found that there is interaction across these four areas: continuous improvement, standards, leadership, and partnerships that reinforce and eventually shape each other in the Mozilla system. For example, in Mozilla, the leadership – which is top down (facilitative leadership) - inspires and promotes openness, '*leading from behind'*, implementing distributed development and centralised integration model in order to tap the need for communities. Within this style of leadership, coaching leadership and innovative leadership simultaneously provide technical and architectural direction, and act on the principle of common understanding instead of command and control, with the aim of continuously improving Mozilla's operations.

Through the use of the concept **distributed development and centralised integration model**, Mozilla leadership roles are also emerging from the community. This allows a balance in the elements of leadership (i.e. decision-making), since leadership not only comes from inside the organisation (i.e. facilitative leadership or umbrella leadership), but also externally (i.e. community leadership).

At the same time, the use of codes of practice, open sources, copy left, open innovation and open platform in daily business, shows that the leadership recognise openness and freedom, as opposed to the more rigid approach of implementing a certain narrow standard. Thus, the inspiration of '*free as freedom'* leads to Mozilla open standards and public standards. Eventually, this allows and invites more expertise for the improvement of Mozilla existing standards. This results in more ideas and actions (through Mozilla lab and Add-Ons) towards the improvement of Mozilla products.

In addition, the leadership also inspires and promotes collaboration and partnership programs, where the focus is on communities of practice, and individuals and organisations in the open source community that integrate and develop a range of partnerships with Mozilla. As a result, suppliers and partners have a much closer relationship because of social integration online (i.e. suppliers and partnerships involved in open source improvement activities throughout the network). Consequently, this leads to continuous improvement in the sense of improving the ideas through collaboration and partnerships, thereby promoting more ways of rectifying problems and innovating new product lines.

Looking at Mozilla's continuous improvement as a whole, the key factors are due to the high involvement of communities of practice, continuous integration within and outwith the organisation and customisation based on user needs and experiences. Overall, it is fair to say, all of these interactions create a system in Mozilla. **Figure 7.6** illustrates the interaction between these four areas at Mozilla.

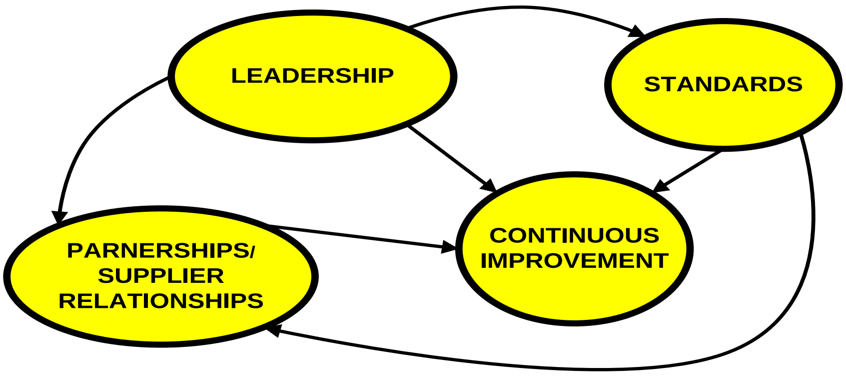


Figure 7.6: The interaction of Mozilla's principles

Having reviewed the interaction of the above principles, the researcher also believes these principles may lead to other areas, which are listed as below:

(1) Customer/user orientation. Customers as the integral part of the network organisation/business model, who engage in the form of participation, collaboration, innovation and learning together.

(2) Involvement. The involvement comes both internally and beyond the boundaries of organisation, as more dynamic members work together and share ideas, knowledge and experiences.

(3) Technological development. The development of new technology/product development is not solely about internal R&D, but also comes from external organisations, which includes contribution of third parties in the development of new technology.

(4) Integration. Continuous integration within quality, technology and enterprise business (i.e. business strategy and marketing) either within the organisation or across the networks.

In **Chapter 8**, the researcher will present the discussion and conclusion of this study in order to evolve their theory and demonstrate a contribution to knowledge.

CHAPTER 8

Discussion and Conclusion

8.1 Introduction

This final chapter presents the discussion of findings, research evaluation and conclusions derived from the research process. This chapter aims to demonstrate a valid construct of theoretical and empirical findings (i.e. a critical review of research quality criteria), which leads to a contribution of knowledge. Additionally, this chapter also presents the limitations of the work and some recommendations for future research in this area.

8.2 Discussion

In **Chapter 5**, the researcher made predictions on how the principles of quality and technology may look in the future. In the previous chapter (**Chapter 7**), the researcher illustrated and discussed the phenomena of specific topics: continuous improvement, standards, leadership and supplier relationships/partnerships in Mozilla. In doing so, it enabled the researcher to portray the overall picture of Mozilla, and how Mozilla is aligned to the predicted future context, which is illustrated in **Table 8.1.** In this chapter, the researcher compares the findings from the Mozilla case against the predictions on quality and technology management, and discusses these in the context of the research questions. The details from the comparison are presented in **Table 8.2** to **Table 8.5** and are explained in more detail thereafter.

8.2.1 Mozilla Overview

Table 8.1 as follows, summarises the predicted changes in business and global trends (conceptual prediction) against the Mozilla case (real world).

Table 8.1: Comparison between prediction of future context and actual situation at Mozilla

Prediction of future context – Dynamic Transition	**Is the future context being implemented in Mozilla?**	**Justification**
Web 1.0 to Web 2.0	YES	Mozilla uses Web 2.0 tools such as forums, chat, blogs, wiki, and news among the medium for improvements (i.e. via Mozilla Zine and Quality Mozilla - QMO).
Ideas and actions originating from the network rather than internally	YES	Involving and integrating ideas and actions from communities of practice to make internet better for everyone.
Central Regulation to Self Regulation	YES	Self-regulation and meritocracy are one of the fundamental cultures of Mozilla.
Contract to Trust	YES	Trust becomes habitual in Mozilla work. The commitment of Mozilla in striving free culture, as illustrated "*Transparent community-based processes promote participation, accountability and trust*".
Legal Regulation to Moral Regulation	YES	Moral regulation is the habit among the Mozilla society (communities of practice), as Mozilla itself practises mutual understanding of codes of practice in contrast of rules and legal regulation.
Increasing Transparency	YES	Transparency is one of the Mozilla principles and has become Mozilla culture (in daily practice).
Proprietary to Open Source	YES	Mozilla promotes and lives up to '*Free as in freedom'* ideal. As Mozilla truly an open source project and support free culture.
Copyright to Copyleft	YES	All Mozilla products and services are established in a way of copyleft and free for public.
Increasing Emphasis on Innovation	YES	The innovation of Mozilla comes from inside and outside of Mozilla (i.e. Mozilla developers and third parties mostly from Mozilla communities of practice). In fact, Mozilla mission is encouraging choice, innovation and opportunity online.
Bureaucracy to Netocracy	YES	Mozilla is truly a model of netocracy, where Mozilla's structure is flat, unique and represents humanitarian society, which is knowledge driven (i.e. tapping the needs of communities) in contrast to money driven society.
Clear Organisational Boundaries to Fuzzy Organisational Boundaries	YES	Mozilla improvement and innovation are beyond their organisational boundaries, as Mozilla also operates, manages processes and integrates within the Mozilla communities.
Increasing Emphasis on Community Opinion	YES	Mozilla welcomes ideas and actions of improvement across the network (i.e. from communities of practice), as everyone is allowed to contribute their opinion for better improvements.
Increasing Emphasis on Continuous Learning	YES	Most of coders/developers are willing to contribute to Mozilla for free, due to the spirit of sharing, gaining personal self-satisfaction and as a part of continuous learning.
Increasing Emphasis on Corporate Social and Environmental Responsibility	YES	Mozilla positions itself as a public benefit organisation that is dedicated not to make money but to improve the way people everywhere experience the internet.

Loyal Customers to Picky/Curious Customers	YES	The growing support from community of practice (i.e. customers and developers) towards the continuous improvements in Mozilla, reflects that customers becoming more demanding and picky; looking for a better ways in doing things, as they are not willing to accept Microsoft Internet Explorer, but want something more (i.e. *free as in freedom*).
Increasing Pace of Change	YES	The pull of ideas in improving and rectifying problems are much quicker, as the result of breeding ideas and solutions are coming from Mozilla communities of practice all over the world across the network.

8.2.2 Continuous Improvement

Table 8.2 below shows the comparison between continuous improvement principles at Mozilla, and continuous improvement principles from the QM and TM conceptual framework.

Table 8.2: Comparison between continuous improvement principles at Mozilla and the QM and TM conceptual framework

Continuous improvement at Mozilla	Continuous quality improvement from QM conceptual prediction	Technology improvement from TM conceptual prediction
1. Improvement not only happens internally, but also externally across the wide network.	i. Improvement through ideas and innovation coming from the network not solely from internal organisation with continuous change.	a. The improvement is persistence and resilient with more ways of doing things, as the options continuously evolve (i.e. through the participation and collaboration amongst the communities of practice).
2. Improvement brings in ideas through communication, discussion and review, action taken and end-results, which cover the entire process.	ii. Continuous improvement will be done in the manner of 'participative and collaborative improvement' across the networks.	b. Technology improvement via external innovation, with multiple parallel paths to solve an innovation problem. In both markets and communities, external innovators will explore innovation landscapes that are often unknown and unexpected by the organisation. A high-performing solution often comes by this type of exploration.
3. High involvement of communities of practice.	iii. More organisations will invite outsiders to comment on their suggested design improvements, so that members from the practice community can share with each other their comments, reviews, and feedbacks on this quality improvement.	c. External innovation also appears to be more cost-effective, because the cost of failure is typically not borne by the host organisation. If an external innovator fails in its attempt to solve an innovation problem, then it alone bears the costs (and benefits of learning) from that attempt.

4. Improvement works through open participation, which involves technical (i.e. Mozilla coders/developer) and non-technical people both internally and externally.	iv. Evidence of some actions taken place in the networks, as the result of communication. New methods of communication can greatly lower the cost of exchanging information and of providing people with information. It is easy and cheap to experiment.	d. External innovation appears to achieve fast solutions that arrive quite quickly and can often exceed the capacity of the seeker.
5. Continuous integration within and outwith the organisation.	v. Architectures that are open, flat, malleable and non-hierarchical, whereby everyone has a voice; the tools of creativity are widely distributed.	
6. Customisation based on users' needs and experiences.	vi. Continuous learning opportunities will be the important driving force for quality improvement, where it simultaneously provide a process of development for contributors and improvement for participators. As everyone learns and participate in quality improvement. Self-learning and self-satisfaction counts for more than credentials and titles.	
	vii. The improvement is persistent and resilient with more ways in doing things, as the options continuously evolve (i.e. increase pace of change).	

In terms of quality management, it is predicted that the principle of continuous quality improvement in the future will come from a wide context of networks (i.e. network-based improvements), where there will be an increase in open innovation, participation and collaboration as the engine of quality improvements. Further, continuous quality improvement will be more self organised, as people and knowledge will be shared freely amongst the network partners. This may lead to better continuous quality improvements in terms of ideas, designs, processes, products, deliveries, support services and the organisation as a whole.

From the perspective of technology management, it is becoming clear that the principle of technology improvement in the future will also be based on networking wide technology improvement. For instance, improvements, in terms of ideas and innovation, will come from the network, not solely from inside the organisation (i.e. innovation as the heart of technology improvement). As a result, managing external innovation will be the key focus, with the tools of creativity widely distributed. As such, there will be more focus on self-management, establishing trust, transparency, open innovation (e.g. external innovation), and also participation and collaboration, as well as knowledge sharing and community opinion across the network.

This highlights that the prediction of the principle of continuous improvement in quality and technology management is consistent with the Mozilla case, where continuous improvement not only happens internally, but also externally across the wide network. For example, ideas of improvement come from communities of networks, such as Mozilla Zine and Quality Mozilla (QMO), which provide a platform for forums, chat, news and blogs. Additionally, the improvement also comes through Bug Bounty Program, Add-Ons Manager, the customised browsing experience, and Mozilla Labs, the concept series. Thus, the principle of continuous improvement in Mozilla works through open participation, which involves technical (i.e. Mozilla coders/developer) and non-technical people, both internally and externally. All of these reflect the notion that improvement brings in ideas through communication, discussion and reviews, action taken and end-results, which cover the entire process.

As such, the Mozilla case serves to advance the view that the key factors behind the success of continuous improvement are:

- High involvement of communities of practice
- Continuous integration within and outwith the organisation
- Customisation based on users' needs and experiences

The above discussion confirms that the principle of continuous improvement, in relation to both quality and technology management in the future, will rest on networking wide continuous improvement, and affirms the prediction that continuous improvement not only takes place internally, but also externally, across the wide network.

8.2.3 Standards

Table 8.3 below illustrates the comparison between principle of standards at Mozilla and principle of standards from QM and TM conceptual framework.

Table 8.3: Comparison between principle of standards at Mozilla and the QM and TM conceptual framework

Standards at Mozilla	Quality standards from QM conceptual prediction	Technology standards from TM conceptual prediction
1 Using codes of practice instead of rigid standard.	i. In current Quality Management standards, the focus is on people's competencies. In the future, the focus will shift more on trust, morality (ethics) and transparency.	a. ICT architecture allows the firm to continuously integrate new business processes and emerging technology standards with existing legacy systems and processes.
2. Open Standard as the basis of key technologies.	ii. Other drivers will come into play such as self-regulation, where the user is both a contributor and participator. Ideally, this means that standards could be self-regulated.	b. Business components have *open linkages* in which they connect with other components or external systems through standard and open interface such as XML and can be improved by Web services.
3. Mozilla Open Standards support their ***Free as in Freedom –*** open culture.	iii. The introduction of reputation systems and business network models (profile based) could be introduced to help people choose high quality providers, where specific quality standards would not be relevant.	c. Intellectual property (i.e. industrial standard) becoming community property (public standard), as a new generation of users and consumers of intellectual property produced by new technologies bring totally different assumptions and attitudes to bear on its ownership. As brands become less the property of an organisation and more the banner of a movement, ownership will become even looser.
4. Mozilla technology standards are open to the public and so it is a public standard.	iv. A new quality standard may need to be released for networking standards, in order to accommodate large-scale business and social interaction in the net (e.g. internet and intranet).	d. In the future, open technologies become the open networking standards. For example, Linux and Apache provide the most popular examples of open technologies and their underlying communities, where members donate time, knowledge, and collaborative effort to develop technology that is placed in the public domain.
5. The implementation of open source, copy left, open innovation and open platform in daily business towards open interfaces and public standard.	v. The future quality standards could be tailored for networking standards, where there is a need to recognise the issues of leadership (i.e. managing coaching leadership), partnership, collaboration, continuous improvement, privacy and security concerns in the networks context.	e. This shifts to the development of open technical standards, where an individual is free to propose new technical standards. For example, Internet Engineering Task Force (IETF) community develop the internet standards.

	vi. A new standard should also consider the evolution of corporate social and environmental responsibility. It is a possibility for this element in the ISO 26000 standard to be merged into the new networking standards as well.	

In terms of quality management, the next generation of principle conformance to standard, could be conformance to a network standard/open standard, extended to control quality in the market, wherein the introduction of reputation systems and business network models (profile based) helps people to choose high quality providers. As such, this will be based on self-regulation, trust, morality, transparency and tailor-made networking standards, with more knowledge sharing and community opinion taking place. Accordingly, future quality standards may follow the model of the Internet Engineering Task Force (IETF). On the one hand, this dynamic model is based on an open technology community that develops open technical standards for the internet, where the IETF processes are transparent and all resulting technology is freely available. The IETF has no formal membership restrictions or voting rights, and any individual is free to propose new technical standards. On the other hand, the creation or amendment of the technical standards takes place in view of the experts, and thus provides a balance between the two.

Through the lens of technology management, the principle of technology standards in the future will focus on the network standard. This standard could be based on open standards, whereby open technologies are driven by the underlying communities of practice, in which members donate time, knowledge and collaborative effort in order to develop technology that is placed in the public domain. As a result, it becomes the property of the community - the open technologies standard. As such, there will be more open linkages for business components through the use of an open standard and open interface, such as XML, as this can be improved by Web services.

This indicates that in the principle of standards, there is some degree of consistency between the original prediction and the actual situation. Mozilla put forward the view that standards can be classified into three key elements, which are:

(i) Open technologies standard: An open technology that becomes a standard, where the technology is open to the public, and practice communities donate time, knowledge and collaborative effort in order to develop the technology that is later placed in the public domain.

(ii) Codes of practice: A guideline that is used for daily operation.

(iii) Standard for control: The use of standards as control mechanisms.

Thus, the way that Mozilla operates is not based on rigid standards, but more on mutual understanding, as exemplified in their use of codes of practice. In dealing with and enhancing their technology performance, Mozilla implements open standards as the basis of key technologies (i.e. XUL, XPCOM, Gecko and Necko). This means that the standards are open to the public. Clearly, Mozilla is driven by the open source and open platform movement, and live up to their support of ***Free as in Freedom*** ideal. In fact, the most interesting point discovered from the Mozilla case, was that it demonstrated that the understanding of the principle of standard is about openness (i.e. not in the rigid form). As such, the Mozilla case illustrates that the key factors behind the principle of standards are:

- The use of codes of practice instead of rigid standards
- The implementation of open source, copy left, open innovation and open platform in daily business towards open interfaces and a public standard

The above discussion suggests that the principle of standards in the future will rest on a networking standard, where the key focus will be on an open standard. On the one hand, this is consistent with the prediction that standards in the future will lie on a network standard, as the open standard and open interface towards public standards will be the key agenda. This addresses the fact that quality standards in the future will shift to open technical standards, with the architecture of participation and collaboration amongst the practice communities, including experts in developing standards. Likewise, technology standards will also progress with the foundation of communities of practice participating in developing open technology standards.

On the other hand, there are inconsistencies regarding the codes of practice. Whilst it is acting as the key role to support the Mozilla standard, this kind of situation is not happening and being implemented in the area of quality management. This is due to the nature of the quality management field, which deals mainly with conformance to standard and more to rigid rules and regulations (i.e. ISO 9000 series, ISO 14000 and OHSAS 18000). However, the researcher has addressed this issue before, and what is important now in terms of the future, is the outlining of an open standard in networking standards as the future standards. As previously mentioned, the standard for the future may rest on: (i) Open technology standards, (ii) Codes of practice and (iii) Standard for control (i.e. open technical standards). This means that there is still a need for a formal standard as a control mechanism, but the standard may also become integrated with other elements, such as codes of practice, open technologies, public standard and copyleft in forming a new standard.

This extends the prediction that standards in the future, for **both quality and technology management,** will rest on the network standard, which is open, and may comprise of open technology standards, codes of practice and standards for control (i.e. open technical standards).

8.2.4 Leadership

Table 8.4 below shows the comparison between principle of leadership at Mozilla and principle of leadership from QM and TM conceptual framework.

Table 8.4: Comparison between principle of leadership at Mozilla and the QM and TM conceptual framework

Leadership at Mozilla	Quality leadership from QM conceptual prediction	Technology leadership from TM conceptual prediction
1. Leadership not only comes from inside the organisation (i.e. facilitative leadership) but also externally (i.e. community leadership), as Mozilla operates	i. Future leadership is anticipated to be closely related to issues of corporate social and environmental responsibility. This matches with the increased focus on compliance	a. Harnessing the technology, where the leadership challenge needs to get the right technology to work towards providing business value.

in ‘Bazaar style’ and following a ‘distributed development and centralised integration model’.	with environmental and corporate social standard (e.g. ISO 14000 and ISO 26000).	
2. Leaders providing technical and architectural direction of Mozilla projects and wide range of services to assist the Mozilla development community.	ii. The leadership will come from across the network as part of the coaching process, as more people seek faster information and solutions through the network, leading to the emerging coaching leadership. Shifting from power based on position to power based on respect, trust, and expertise.	b. Leadership in handling technology development, where management, scalability and openness are the issues. To a certain extent the decisions of technology direction is about how to design, build, launch, market, support and maintain products and services, and to be effective in working within and directing communities of employees, users and partners in accomplishing large scale outcomes.
3. Leaders develop and implements processes to enhance public discussion, distributed development, and peer review.	iii. Ideas compete on an equal footing. Quality leadership will be more transparent with a high degree of openness and sharing, where the information and decision-making processes will be on view to the public.	c. The ideas and actions concerning leadership in technology areas not only come from inside the organisation but also across the networks. Community leadership roles may be granted based on how active an individual is within the community as well as the quality and nature of his or her contributions.
4. Leadership in a way of meritocracy, in which the leadership roles are granted based on how active an individual is within the community as well as the quality and nature of his or her contributions (i.e. community leadership).	iv. From command and control to coordinate and cultivate. Cultivate means taking advantage of people’s true intelligence and creativity, which are the most critical capabilities of successful businesses.	d. ‘A swarm of bees and a school of fish leadership’ are the metaphors that can describe coaching leadership in networks. As more people seek faster information and solutions through networks, then this leads to the emergence of coaching leadership.
5. Leadership acting on the principle of common understanding and ‘leadership from behind’, which means guiding, directing and envisioning people, facilitating and coaching instead of command and control.	v. From narrow, constraining job descriptions to a dynamic, tradable portfolio of operational, project, and leadership roles that tap into people's full potential.	e. The leader of the network - the emergence of a communities leader – who is referred to by others without having the trappings of power. This means that this movement is moving to a situation where there is no real leader. Everyone can participate and collaborate with each other and the position of leader can be rotated amongst them. This could truly happen if all the members have more or less the same capabilities in the performance of their work.
6. Transparent leadership where decisions are proposed and discussed in public forums and the resolutions communicated in those forums; as a result, more emergent, consultative and open leadership is created.	vi. Power is granted from below where the authority is fluid and contingent or value-added and just about everything is decentralised. vii. From reactive top-down assignments to proactive bottom-up initiatives by self-organising teams.	

In terms of quality management, it is anticipated that future quality leadership is likely to be closely related to issues of corporate social and environmental responsibility. This aligns with the increased focus on compliance with environmental and corporate social standards (e.g. ISO 14000 and ISO 26000). In relation to this, leadership will come from across the network, as part of the coaching process, as more people seek faster information and solutions through the network, leading to the emergence of coaching leadership. This will result in a shift from power based on position, to power based on respect, trust and expertise.

From the perspective of technology management, technology leadership in the future puts forward a view on harnessing the technology, where the leadership challenge needs to acquire the correct technology in order to work towards providing business value. Future leadership may focus on handling technology development, management, scalability and openness. To a certain extent the decisions involving technology direction are about how to design, build, launch, market, support and maintain products and services, and how to be effective in working within and directing communities of employees, users and partners, in order to accomplish large-scale outcomes. In relation to this, the ideas and actions concerning leadership in technology, not only come from inside the organisation, but also from across the networks. As a consequence, community leadership roles (i.e. the emerging community leadership) may be granted based on how active an individual is within the community, as well as the quality and nature of his or her contributions.

This highlights that, on the principle of leadership, the prediction is consistent with the Mozilla case. Mozilla put forward the view that leadership not only comes from inside the organisation (i.e. facilitative leadership), but also externally (i.e. community leadership). Mozilla can be described as following a 'distributed development and centralised integration model' which operates in a 'Bazaar style'. As such, the Mozilla case indicates that the key aspects concerning the principle of leadership are:

- Coaching leadership and innovative leadership where leaders provide technical and architectural direction.
- Leadership acting on the principle of common understanding and 'leadership from behind', which means guiding, directing and envisioning people, facilitating and coaching instead of command and control.

- The emergence of community leadership in which the leadership roles are granted based on how active an individual is within the community (i.e. meritocracy basis) as well as the quality and nature of his or her contributions (i.e. innovative leadership mindset).
- Transparent leadership where decisions are proposed and discussed in public forums and the resolutions communicated in those forums; as a result, more emergent, consultative and open leadership is created.

The previous discussion outlines that the ideas and actions concerning leadership not only come from inside the organisation (i.e. facilitative leadership), but also from across the networks (i.e. community leadership). Leadership roles could be granted based on how active an individual is within the community, as well as the quality and nature of his or her contributions, and is referred to by others as a leader without having the trappings of power. In relation, the researcher believes leadership in the future needs to work closely as a society, and tap into the needs and wants of societies through the use of ‘the distributed development model’ (i.e. individuals to make their own decisions on what to do) by giving more opportunities for people in the network to participate, collaborate, provide choice and ways to innovate amongst themselves. This follows the ‘centralised integration model’, whereby the leader pulls ideas and actions together. This also suggests that leadership in the future will be more fluid and organic, as it can emerge, and not only be formally appointed.

This confirms the prediction that future leadership for **both quality and technology management** will be more fluid and organic, as leadership not only comes from inside the organisation (i.e. facilitative leadership) but also across the networks (i.e. community leadership).

8.2.5 Supplier relationships/partnerships

Table 8.5 below illustrates the comparison between principle of supplier relationships/partnerships at Mozilla and principle of supplier relationships/partnerships from QM and TM conceptual framework.

Table 8.5: Comparison between principle of supplier relationships/partnerships at Mozilla and the QM and TM conceptual framework

Supplier relationships / Partnerships at Mozilla	Quality supplier relationships/Partnerships from QM conceptual prediction	Technology Partnerships/ Supplier relationships from TM conceptual prediction
1. Supplier relationships/ partnerships in Mozilla happen mainly through Mozilla based-applications (applications that are built by individuals and organisations using Mozilla technologies) and from third party applications (applications built by third parties that are embedded with in a Mozilla product).	i. The relationship is shifting from supplier relationships to supplier involvement (supplier partnering) in open source improvement activities throughout the network.	a. Suppliers and partnerships having a much closer relationship because of social integration and tightly integrated online supply chains.
2. Business model is focused on communities of practice; individuals and organisations in the open source community that integrate and develop a range of partnerships with Mozilla.	ii. Supplier/partnerships are competing and complementary (coopetition) with producers and each other at the same time.	b. Relationships built upon trust, openness and transparency (openness in information). This provides the platform for suppliers to communicate, review and evaluate their partnerships.
3. The emerging partnerships through open source and open platform.	iii. Open source innovation provides the platform for suppliers to be more actively involved in the company's activities.	c. The partners working closely with greater emphasis on knowledge and people sharing in building collective intelligent amongst themselves.
4. The encouragement for individuals and organisations to take part in each others' business model and form partnerships.	iv. Interconnection is accomplished easily with other systems from within the firm and vendors. This may lead to better supplier relationships, as supplier involvement becomes the norm and the two-way relationship happens regularly and is not just a one-off meeting. Crucially miscommunication and misinterpretation can be reduced.	d. Communication, interchanging ideas and solution take place amongst the suppliers and partnerships as the result of open source innovation movement and eventually help more rapid decision making and avoid misinterpretation.
5. Relationship is not only on the basis of collaboration and complementary but in certain ways competing at the same time.	v. Future supplier relations will involve facilitating collaboration across the firm and its partners and thus identify new opportunities for process innovation and customer value.	e. There will be more third parties; individuals and organisations, participating and collaborating in each other's business models.

In terms of quality management, the principle of the quality supplier relationship would be based on collaboration in supplier relationship/collaborative networks, where suppliers and customers integrate their business model, while competing and complementing each other. This is light of the fact that the relationship is shifting from supplier relationships to supplier involvement (supplier partnering) in open source improvement activities throughout the networks. As a result, there will be more need to establish trust, transparency and open source innovation amongst the partners.

From a technology management perspective, technology partnerships/supplier participation would also be based on collaboration in supplier relationships with a greater emphasis on suppliers partnering into the business models. Future suppliers and partnerships will have a much closer relationship because of social integration and tightly integrated online supply chains. As a result, the partners are working closely, with a greater emphasis on knowledge and people sharing, in order to build collective intelligence amongst themselves. Further, this relationship will be more complex, with competing and complementary activities happening at the same time. To a certain extent, there will be more third parties – that is, individuals and organisations who are likely to participate and collaborate in each other's business models. Consequently, the relationships are built upon trust, openness and transparency (openness in information), which provides the platform for suppliers to communicate, review and evaluate their partnerships (i.e. reviewing the product design at the early stage).

This indicates that, in the principle of supplier relationships/partnerships, the prediction is consistent with the Mozilla case. In Mozilla, the business model is focused on communities of practice, where individuals and organisations in the open source community integrate and develop a range of partnerships with Mozilla. As a result, suppliers and partnerships have a much closer relationship because of social integration and being tightly integrated online; i.e. suppliers and partnerships involved in open source improvement activities throughout the network. Further, the Mozilla case also indicates that the key factors in the principle of supplier relationships/partnerships are:

- The encouragement for individuals and organisations to take part each others' business model and form partnerships

- The emerging partnerships through open source and open platform

The previous discussion suggested that supplier relationships/partnerships in the future will enjoy a much closer relationship because of their tightly integrated online supply chains. As such, the emerging partnerships happen through open source and open platform, and through encouraging individuals and organisations to take part in each other's business model and form partnerships. In short, partnerships in the future are likely to consist of developing a range of partnerships with individuals and organisations in the open source community. Additionally, the future of partnerships will not only rest on the basis of collaboration and complementarities, but are likely to include partners competing at the same time. For example, Mozilla and Google have formed a relationship as partners in some network projects, but at the same time compete in the web browser market.

This confirms that supplier relationships/partnerships in the future for **both quality and technology management** will be based on coopetition, the interplay of collaboration and competition, which happens at the same time. This includes encouragement for individuals and organisations to take part each others' business model and form partnerships through open source and open platforms.

In summary, the thematic analysis presented in **Chapter 7,** together with the discussion of the Mozilla case study and comparison study, validate that there are some consistencies in which the future context of quality and technology management, i.e. continuous improvement, standards, leadership, supplier relationships/partnerships, may lie in the network. Further, the Mozilla case also illustrated that Mozilla is aligned with the predicted future trends, as presented in **Table 8.1.** This outlines two perspectives, which are (1) Mozilla, at present, already operates in the context of future, (2) The predicted changes in business and global trends are already being realised by Mozilla in their operations. Therefore, this makes it possible for other companies from various industries to learn from and understand how to implement Mozilla's business model.

Thus, the researcher concludes that the four principles are moving towards the networking base, as they are carried out and integrated across the network. These also bring out certain points, such as engaging people as peer production, with the sharing of knowledge and talented people across the globe. Although it is understandable that different contexts (e.g. manufacturing sector) may produce different results, this study provides an understanding and insight into how the principles of quality and technology management may look in the future.

In the following section, the researcher will discuss the findings from the study in the context of the research question.

8.3 Overview of the research in answering the research question

The key aim of this research is to understand how the quality management and technology management fields have developed and evolved to date, as well as predicting how they may develop in the future, thus identify potential opportunities for convergences between both fields.

The researcher approaches the research with the question: **is there any opportunity and potential of bringing the quality management and technology management fields together to better understand the potential for synergies, convergences, overlaps and conflicts between these two fields?**

In order to answer this question, the researcher conducted a literature review of the two fields (i.e. quality and technology management) and identified the need for understanding in relation to how each field emerged and evolved over time, and concluded the review with a framework for mapping each field based on focus, principles, systems, tools and techniques. In doing so, the researcher identified that both literatures have evolved over time, with their ***fundamental focus*** evolving as the literature evolved. Further, as they evolved, it was noted that the principles, systems, tools and techniques have also changed. This leads to the central question in relation to this research: '**how have quality management and technology**

management principles, systems, tools and techniques evolved and how will they relate to each other in the future context?'

To better answer the key research question, the researcher conducted an in-depth literature review of the two fields, and discussed the evolution of the literature on quality and technology management in terms of focus, principles, systems, tools and techniques, as summarized in **Table 4.1** and **Table 4.2** in **Chapter 4**, and predicted the transition of the future context (as presented in **Table 5.2** in **Chapter 5**), which reflects the predicted movement of future changes. Accordingly, this historical review allowed the researcher to project the potential future trends for each of these fields based on the projected business and global trends.

Having discussed the patterns and trends in relation to how things have developed and evolved through eras in quality and technology management, it appears that what drives the evolution of systems, tools and techniques of quality and technology management are the principles (i.e. principles are the driving force behind the evolution of systems, tools and techniques in these two fields).

Further, having undertaken the analyses and syntheses of quality and technology management principles, this allowed the researcher to meet the aim of identifying potential areas of synergies, convergences and overlaps in relation to future developments in the quality and technology fields. What is striking now is that there are potential convergences and synergies between these two fields. Four areas of synergy that strongly emerged from this analysis were: continuous improvement, standards, leadership and partnerships/supplier relationships - all of these principles are moving towards a network-based operation. As such, the analyses also revealed that networking is emerging as a future business model that may have a significant impact on the future of quality management and technology management.

Following on from that, the researcher explored these four research areas through a case study in a network-based organisation (Mozilla) and expressed the findings in **Chapter 7**. The researcher has then mapped and compared the conceptual prediction against the Mozilla case to see the relationships and make sense of these, as previously discussed in **Section 8.2**. In doing so, this provided clarity on the issue of how the principles of continuous improvement, standards, leadership and partnerships/supplier relationships in the areas of quality and technology management may look in the future, as well as confirming the conceptual prediction in **Chapter 5**.

All of these provide insights and help answer the key question: '**how have quality management and technology management principles, systems, tools and techniques evolved and how they relate to each other in the future context?'** which is discussed in the following paragraph.

In the emerging network context, there is the potential for quality and technology management to come together, whereby quality and technology management principles, such as continuous improvement, standards, leadership and supplier relationships/partnership, could merge into one set of principles (i.e. future common grounds/the overlapping points of these four areas for the two fields). As such, the researcher proposes that they may evolve into higher levels, i.e. 'management of continuous improvement', 'management of standards', 'leadership' and 'management of partnership', as shown in the **Figure 8.1**. This means that all of these principles would merge into one set of principles, with the content changing into a more network-based context.

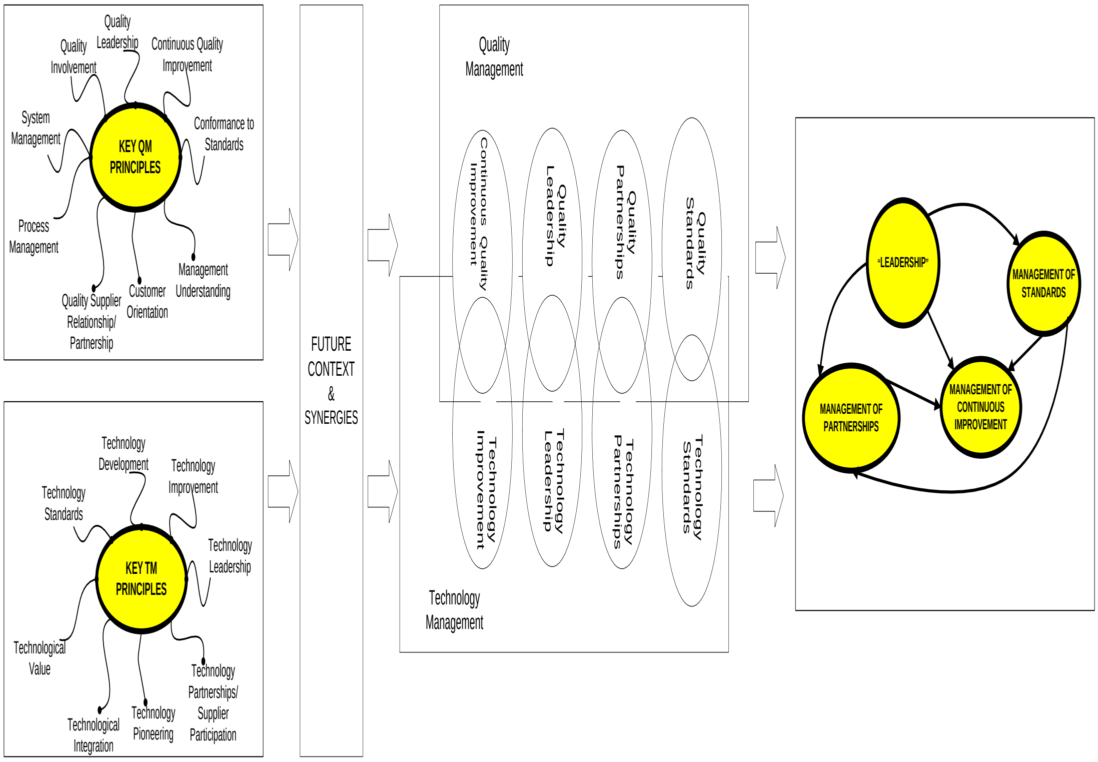


Figure 8.1: The relations between the current context and future context

As mentioned earlier in **Sections 8.2.2 to 8.2.5**, the comparison between the findings from the Mozilla case and the predictions on quality and technology management revealed that all of the principles mentioned are moving towards a network-based operation.

In the future, both continuous quality improvement (CQI) and technology improvement (TI) will merge into a form of network-wide continuous improvement, as continuous improvement not only happens internally, but also externally across the wide network. Similarly, quality standards (QS) and technology standards (TS) in the future will rest on network standards (i.e. open technology standards, codes of practice and standards for control coming together as network standards), in which the standards are open – i.e. open standards and open interfaces moving towards public standards. However, the point of convergence/overlapping in relation to standards between quality and technology management may be smaller in comparison to the rest of the principles that were mentioned previously. This is due to the fact that quality management standards would be moving towards more open technical standards (i.e. standards for control), whereas technology management would move inexorably into open technology standards in pursuing their own logic/nature of the fields. The common ground between the two may lie in open standards and the high involvement of communities of practice.

Both quality leadership (QL) and technology leadership (TL) in the future will be more fluid and organic, as leadership not only comes from inside the organisation - formally appointed (i.e. facilitative leadership) - but also across the networks - emerging (i.e. community leadership). Likewise, both quality partnerships (QP) and technology partnerships (TP) in the future will be based on coopetition, the interplay of collaboration and competition, with encouragement for individuals and organisations to take part in each others' business model and form partnerships through open source and open platform.

To a certain extent, the overlapping points/convergences amongst the afore-mentioned principles in relation to the quality and technology management fields advances the view that the so-called 'leadership' will recognise more openness, freedom and high involvement of communities of practice - the interplay of 'management of standards' - wherein 'leadership' will also inspire and promote collaboration and partnership programs, whilst encouraging individuals and organisations to take part in each others' business model. In addition, 'management of partnerships' in the future will be based on coopetition, the simultaneous interplay of collaboration and competition. In turn, the 'management of continuous improvement' will consist of network-wide continuous improvement, as continuous improvement not only happens internally, but also externally across the wide network. Consequently, the 'management of continuous improvement' will occur due to the high involvement of communities of practice, continuous integration both within and outwith the organisation, and customisation based on user needs and experiences. As a result, all of these address the interactions in these four areas - 'management of continuous improvement', 'management of standards', 'leadership' and 'management of supplier partnership' - which reinforce and ultimately shape each other. Further, all of these interactions create a system – i.e. a business model for the future.

Therefore, the research question can be answered in four propositions:

1. ‘Management of continuous improvement’ will rest on network-wide continuous improvement, as continuous improvement not only takes place internally, but also externally across the network.
2. ‘Management of standards’ will rest on network standards through the use of open standards and open interfaces towards achieving a public standard, with a high involvement of communities of practice (i.e. open technical standards and open technology standards).
3. ‘Leadership’ will not only come from inside the organisation (i.e. facilitative leadership) but also across the networks (i.e. community leadership), where leadership in the future will be more fluid and organic, underlying the notion that it can emerge, and does not depend solely on formal appointment.
4. ‘Management of partnerships’ will be based on coopetition, the simultaneous interplay of collaboration and competition. This involves encouraging individuals and organisations to take part in each others’ business model and form partnerships through open source and open platform.

It should be noted that those propositions have been deduced from literature and demonstrated through the Mozilla case, confirming that they are already happening in practice.

8.4 Quality of research

The critical quality review of this research rests on construct validity, internal validity, external validity, reliability and the originality of this research (i.e. contribution to knowledge), which represent the practical as well as the theoretical implications of the study (Baker, 2003; Bryman & Bell, 2007; Easterby-Smith, et al., 2002; Lewis & Ritchie, 2003; Silverman, 2010; Yin, 2003). The above-mentioned criteria have been discussed and outlined in **Table 6.13** in **Chapter 6**. The following sub-sections discuss further the capability of this research to fulfill the criteria.

8.4.1 Construct validity

Construct validity is about the ability to establish correct operational reading for the concepts being studied (Bryman & Bell, 2007; Yin, 2003; Zikmund, 2003).

Yin (2003, p. 35) claims that it is a challenge to have construct validity in case study research, due to the nature of subjective judgement in collecting data. To cope with this issue, he accentuates that the investigator must undertake two steps: (1) Select the specific type of phenomena to be studied, and (2) Demonstrate that the selected measures in relation to these phenomena do indeed reflect the specific type of change that have been selected. Further, Yin also suggests that multiple sources of evidence can be used in order to increase construct validity when undertaking case study. In addition to this, Bryman and Bell (2007, p. 165) insist that construct validity can be achieved by first deducing the hypothesis/proposition from a theory that is relevant to the concept.

In the course of this Ph.D., the researcher positioned himself as an interpretivist and adopted a deductive and exploratory research strategy, by using a case study as a research design (as discussed in **Chapter 6**).

Thereafter, the proposition (i.e. the conceptual framework of phenomena being studied) that derived from the theory (i.e. prediction) is illustrated through a detailed analysis of a single case study, which enabled the researcher to link data to propositions and criteria for the purposes of interpreting findings towards theory building.

Based on the above discussion, the first argument is that the researcher has established a clear operational reading for the concepts being studied. Deductively, the researcher scopes the literature correctly and covers the sufficient depth and breadth of literature (discussed in detail in Chapter 2 and 4).

The second argument is that, the researcher has used multiple sources of evidence, with five key data collection methods (mixed methods), using: (1) Primary data from official company websites, (2) Primary data from 'hands-on trial observation', (3) Primary data from expert opinion survey via e-mail (electronic mail survey), (4) Primary data from face-to-face interview with scholar, and (5) Secondary data from documents (i.e. journal article, magazines and web sites).

All of these illustrate the fact that construct validity in this research is achieved by: (1) Deductive: Theory-driven, (2) Real-world Mozilla case study research (actual practice), (3) Input from real world; conducting expert opinions via electronic survey, case study and face-to-face interview with the scholars (discussed in detail in **Chapter 6**).

8.4.2 Internal validity

In general, internal validity concerns the ability to make predictions or inferences (Lewis & Ritchie, 2003; Yin, 2003). Bryman and Bell (2007, p. 410) further elaborate this by stating that internal validity is concerned with whether or not there is a good match between the researchers' observations and the theoretical ideas they develop. Likewise, Yin (2003) also suggests pattern matching can be used in order to increase internal validity when undertaking a case study.

In this research, to cope with the issue of internal validity, the researcher has adopted four methods of analysis, namely: (1) Thematic analysis, (2) Pattern matching, (3) Time series/historical analysis, and (4) Causal and effect analysis. The researcher has followed Holliday (2002), who suggests that moving chronologically over time (i.e. event-historical analysis/time series), allows the researcher to organise the data into themes (i.e. thematic analysis), look for patterns (i.e. pattern matching), see the relationships (i.e. causal and effect analysis/outcomes matrix), and make sense of the subject area. As such, the researcher has also adopted Bryman and Bell (2007), by mapping the conceptual prediction (theoretically developed) against the actual situation (researcher's observation) in the Mozilla case. Therefore, all of these enable the researcher to enhance the internal validity of this research.

8.4.3 External validity

External validity refers to the ability to generalise the results to other groups within the population, or to other contexts or settings (Bryman & Bell, 2007; Lewis & Ritchie, 2003; Yin, 2003). In addition, Stierand and Dorfler (2010), based on Morse (1999), argued that in the subjective research, "*it is impossible to claim generalisability for a well-defined area of validity*". However, in the subjective research, the generalisation is achieved through learning, and it is the knowledge that is generalised (Morse, 1999; Stierand & Dorfler, 2010).

As such, Yin (2003, p. 37) also claims that external validity can be increased by correctly using theoretical sampling. Accordingly, survey research relies on statistical generalisation, whereas case study relies on analytical generalisation (Yin, 2003).

Having carried out the analysis of the Mozilla case study (real-world case) and mapped the findings against the prediction (i.e. derived from theory), this allows the researcher to move the conclusions of the study towards generalisation. Thus, the researcher agreed with the argument put forward by (Morse, 1999; Stierand & Dorfler, 2010), wherein in the subjective kind of research (i.e. interpreting the phenomena of study), the generalisation works through learning, and it is the knowledge that is generalised. As the findings of the study, the knowledge of the research can be applied in other cases. As such, this research also followed Yin (2003), by using sampling strategies; the key reason for selecting Mozilla was based on the premise that it fulfilled the **criterion purpose** and provided the **exceptional/deviant case.** Also, the fact that the researcher had observed the phenomena in the network organisation, the knowledge obtained here suggest that it will be valid to other cases, but not necessarily valid to all cases. Therefore, all of these enabled the researcher to enhance the external validity of this research.

8.4.4 Recoverability

Recoverability refers to the ability to conduct research in such a way that the whole process is subsequently recoverable by anyone interested in critically scrutinising the research, which makes it possible for outsiders to follow that research and decide whether they agree or disagree with the findings (Checkland & Scholes, 1999). Similarly, Yin (2003) also suggests that the term 'replication logic' be used to ensure the reliability of a study.

In this research, the researcher has adopted Checkland's 'recoverability' and Yin's 'replication logic' concepts in dealing with the replication/repetition issue, where the researcher outlines the research process of his study, as presented in **Figure 6.4** in **Chapter 6.** This makes it possible for outsiders to follow the research and see whether they agree or disagree with the findings, and, if they disagree, to facilitate well-informed discussion and debate.

8.4.5 Learning from experience

Learning from experience refers to the ability to make sense of experiences (i.e. the complex happenings throughout the study), so that the study as a whole represented a process of learning (Checkland, 1981; Checkland & Scholes, 1999).

In this study, the researcher has adopted Checkland's 'learning from experience' concept in order to increase research validity. As previously mentioned, the researcher has deduced ideas/concepts and tested them by using the Mozilla case study, where some of this knowledge would be applicable to other companies, who could derive information from it. This is very important, as this concept does not come from an interpretivism framework. Throughout the research, the researcher approached the study from a deductive perspective, and illustrated it with a single case study, and learnt a great deal on how this part works in the process. As the lessons extracted and therefore the conclusions reached in this research are based on a single case study, it would be inappropriate claim that the findings are universally applicable for all companies. However, the research methodology (Morse, 1999; Stierand & Dorfler, 2010) literature would support the argument that although the conclusions reached cannot be claimed to be universally applicable it is likely that similar studies conducted in organisations similar to Mozilla (i.e. organisations with open-source network-based business models) are likely to yield similar results. As such, through the use of the 'learning from experience' concept, the researcher is better able to make sense of his experiences, whilst engaging with a real world case (i.e. Mozilla), and therefore, as a whole, this study represented a process of learning.

8.4.6 Contribution to knowledge

Contribution to knowledge concerns the ability of this research to demonstrate an original contribution to the field (i.e. new theories and ideas) (Easterby-Smith, et al., 2002; Silverman, 2010). In general, it is fair to say that the central question in relation to contribution to knowledge remains '*what do we know as the result of this research that we did not know before'?* This question leads to another: *how would it change the way we manage quality management and technology management with respect to continuous improvement, standards, leadership and partnerships today?*

The key points and the essence of this research are illustrated in the following **Figure 8.2.**

Key Points of This Research

TODAY-TO-TOMORROW

This is how continuous improvement is being done today

CQI

~ Constant review and investigation of the performance of the business.
~ Enhancing quality across work streams, promoting quality with suppliers and partners and amplifying product and service quality to customer.
~ Increase the skills and capabilities of all of the organisation's employees so they can effectively engage in problem solving in their work areas.

TI

~ Enhancing the performance of the particular technology by continuously improving technology capability and reliability.
~ Include process improvement and result of improvement - the end result.

This is how continuous improvement will be done in the future

CQI

MoCI

TI

- Networking wide continuous improvement.
- Continuous improvement not only happens internally, but also externally across the wide network.
- High involvement of communities of practice.
- Continuous integration within and outwith the organisation.
- Customisation based on user needs and experiences.

Note:
CQI: Continuous Quality Improvement
MoCI: Management of Continuous Improvement
TI: Technology Improvement

This is how standards is being done today

QS

~ Conformance to systematic improvement standards (i.e. ISO series).
~ A gateway for market entrance.

TS

~ Codified specifications that prescribe rules of engagement among components of a system.
~ Associated with reducing uncertainty by controlling variety; enhancing competition by clearly defining what is required to serve a market (information); which are accepted and shared within a community.
~ It constrain the practices of organisations by inscribing rules that force adopters into specific trajectories of technology use. On the other hand, it also enable enterprises by equipping them with functional capabilities that arise from interoperability.

This is how standards will be done in the future

QS

- Open technical standards (i.e. standards for control).

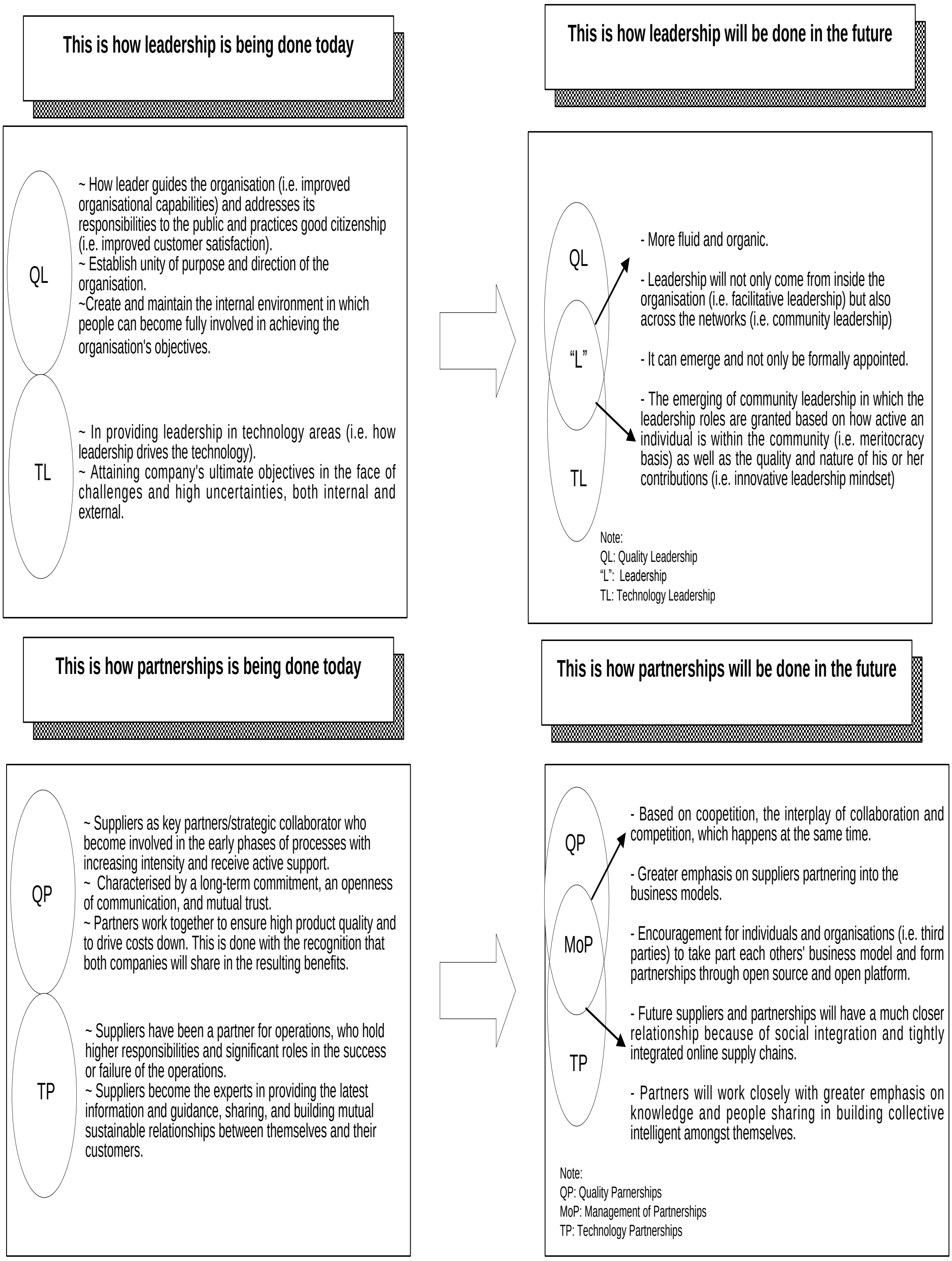
MoS

- The balance of network standards, which is open and may comprise of open technologies standard, codes of practice and standards for control (i.e. open technical standards).
- Open standards and high involvement of communities of practice.

TS

- Open technology standards.

Note:
QS: Quality Standards
MoS: Management of Standards
TS: Technology Standards



Other contributions of this thesis are as follows:

- Eliciting the key principles of technology management (**Section 3.3** in **Chapter 3**).
- Envisioning the future context for quality and technology management (**Section 5.4** and **5.5** in **Chapter 5**)
- Illustrating the converging points of quality and technology management areas (the commons areas for quality and technology management in the future); i.e. continuous improvement, standards, leadership and partnerships/supplier relationships (**Section 8.3** in **Chapter 8**).

Figure 8.2: Key points and the essence of this research

In summary, **Table 8.6** below shows how this research fulfilled the quality criteria as extended from **Table 6.13** in **Chapter 6**.

Table 8.6: Quality criteria for this research

Criteria	Is it satisfied?	How is it satisfied?
Construct validity	Yes	- Using multiple sources of evidence - Enfolding theory (Deductive: Theory-driven), - Real world Mozilla case study research (actual practice) - Input from real-world; conducting expert opinions via electronic survey, case study and face-to-face interview with the scholar - Data display through standard figures and tables
Internal validity	Yes	- Using four methods of analysis, namely: (1) Thematic analysis, (2) Pattern matching, (3) Time series/historical analysis, and (4) Causal and effect analysis by organising the data into themes (i.e. thematic analysis), looking for the patterns (i.e. pattern matching), seeing the relationships (i.e. causal and effect analysis/outcomes matrix) and making sense of it - Enfolding theory
External validity	Yes	- Using sampling strategies to enhance external validity - Enfolding theory
Recoverability	Yes	- Providing the research process and key choices study - Data were organised and structured, which made it easy to find patterns and explanations
Learning from experience	Yes	- Deriving ideas/concepts and illustrating them by using Mozilla case study, where some of this knowledge would be applicable into other companies that would learn about it - The researcher is better able, making sense of his experiences whilst engaging with real world case (i.e. Mozilla), as this study as a whole represented a process of learning
Contribution to knowledge	Yes	- The ability of this research to demonstrate an original contribution to the field (as illustrated in **Section 8.3.6)**

8.5 Implication of research

Authors such as Baker (2003), Bryman and Bell (2007), advance the view that the implications of research represents the practical as well as the theoretical aspects of the study. In this thesis, the researcher has uncovered new knowledge (i.e. new ideas and concepts) which can be used for future research, and which has both theoretical and practical implications.

✎ *Theoretical Implication*

As a result of this research, the theoretical implications for future work are as follows:

1. The fact that there will be a high degree of overlaps and convergences between the areas of continuous improvement, leadership and partnership in quality and

technology management in the future, suggests that future research engaging with these areas needs to consider both quality and technology management simultaneously. For example, future researchers studying the continuous improvement area should consider both quality and technology improvement (i.e. the improvement of the process, technology and product), and not just one or the other.

2. Investigating a single organisation is futile, since the organisation only forms part of a network. For example, there is less value for future research in continuous improvement based solely in a single company, because, in the future, the issue is likely to involve the improvement that comes from the network. Therefore, the interactions and relationships throughout the network should be considered.

3. Further, future research should not focus on a specific issue (e.g. continuous improvement for product design) and neglect the other issues/factors around it, but should consider the entire system. This means that the future researcher needs to approach the subject in a more holistic manner in order to understand the whole process, both internally and externally, as the future is not only about managing a specific problem in a single company, but how companies manage and deal with the range resources of improvements and innovations across the networks, with the architecture of participation and collaboration that comes from all over the world (i.e. high involvement of communities of practice).

Practical Implication

The fact that the future will be more concerned with how network, continuous improvement, standards, leadership and partnerships will be managed in a network context (i.e. open source and open innovation environment). For example, recently, Sony moved from a lean production to an open source, where Sony Corporation and Google Inc. announced an alliance to provide a range of new and rich entertainment experiences that combine Google's open-source Android OS platform with Sony's expertise in technology and product design. The two companies are exploring the joint development of compelling new Android-based hardware products for the home, mobile and personal product categories, and are also considering extending the alliance in connection with Sony's wide range of entertainment assets in order to establish new forms of cloud-based user experiences (Anonymous, 2010c, 2010d). Through this alliance, Sony aims to leverage the stability, future growth potential and open-source accessibility of Google's Android platform to further optimise its product development processes, while also providing consumers with an open, expansive and evolving user experience (Anonymous, 2010c, 2010d). This raises some interesting questions:

1. Does the collaboration and partnerships in the network fairly benefit both parties? Are they willing to share their expertise (core competencies) with each other? Can this collaboration be extended to form partnerships with others in the network?
2. Are they developing the standards? If not, why? What is the impact of this?
3. Are they managing continuous improvement across the network? How do they manage it?
4. Do they recognise leadership across the network, and not just from one company? How do they manage it?

All of the above suggest that the collaborators/partners need to think about how to manage the standards, comprising of open technology standards, codes of practice, and standard for control, and to deal with the issues of managing leadership, continuous improvement and partnerships, both internally and externally.

Also, in terms of strategies and policies, the research also provides insight into the context of the future developments of the historical quality and technology framework. This, on the one hand, may help technology gatekeepers and strategic policymakers to benchmark/evaluate where their organisations are now using the framework. It also means that they do not need to start from scratch in predicting how quality management, technology management - together with business and globalisation trends - will be in the future, as this study already provides understanding and insights in this area.

8.6 Limitations of the research

There were several barriers to conducting this research, in which the concept message of the limitation of this research are listed as follows:

Eliciting key principles of Technology Management

- To elicit the key principles of technology management is proving to be very difficult.

- In this research, the researcher has conducted expert opinion survey via electronic mail (i.e. findings from six scholars), face-to-face interview with scholar and together with technology management literature.

- This allowed the researcher to elicit the key principles of technology management. Yet, it will be very useful if the research could have more experts taking part in the expert opinion survey and follow up on that by conducting panel group discussions.

- However, this study followed (Lewis & Ritchie, 2003; Patton, 2002; Taylor & Bogdan, 1998) who suggest that the research approaches need to be triangulated – drawing on other types and sources of data (i.e. mixed methods) not solely based on a single approach to confirm the clarity of research findings. Therefore, this is generally acceptable.

Research Focus

- It is focusing on the principles of quality and technology management, therefore it is not focusing too much on tools and techniques.

- Hence, it is focusing on the principles of quality and technology management, it might be underplaying the important of the systems.

- This is due to the fact that the researcher believes that the future of quality and technology lies on the principles and follows the works of (Hamel, 2007; Malone, 2004).

- In moving from principles to practices, any changes from the principles may eventually lead to changes of tools and techniques and systems respectively. Therefore, future research should also cover the tools and techniques and systems of quality and technology management in a greater detail.

Methodological Approaches

- This research tends to be more theoretical (i.e. literature review based) and critical review/rational rather than empirical basis.

- This is due to the fact that the research question and research problem tended towards a theoretical study.

- However, as noted by (Silverman, 2010) this is quite common in doctoral dissertation as the research maybe dominant in one or the other.

- By being so, it can also provide a conceptual framework for forthcoming more empirically focused research projects, as the researcher has also planned to do some additional research in the area in the years to come (e.g. looking at the mobile phone industry or ERP systems).

Research Findings

- The findings of this study are limited in the sense that it is valid to those companies that underlined into future contexts characteristics.

- However, the issue of generalisabity has been discussed and those findings followed the research methodology literature (Morse, 1999; Stierand & Dorfler, 2010), which support the argument that, although the conclusions reached cannot be claimed universally applicable, it is likely that similar studies conducted in organisations similar to Mozilla (i.e. organisations with open source networks-based business model) are likely to yield similar results.

- The approach to the research can be adopted as a kind of meta-level of findings in contexts that are not radically different from this research and these may lead to different results but maintaining the research process as valid.

- Further, the findings that extend quality and technology management theory, and the general insight into the specific areas of quality and technology namely; continuous improvement, standards, leadership and partnership are propositions that are plausible in the context of the bodies of literature in which they are positioned, but required further empirical validation.

- Also, another dimension of the generalisability of findings is that by learning from this research and this kind of context and this kind of organisation, one could conduct a more competent research in similar cases with less effort in the future.

Overall research process

- The overall research process had some constraints where time and financial issues remain his major concern in completing the research.

- This is due to the fact that the study had to be completed in the period required for doctoral submission and the researcher's sponsorship also only last for 42 months.

- In fact, UK Visa matters and his official study leave from Malaysia's university (University Technical Malaysia Malacca) were one of the obstacles itself.

8.7 Suggestions for future research

This study has provided the foundation for further research as follows:

- An investigation of quality and technology management, specifically in the area of technology disaster (i.e. the failure of quality and technology), which also links to risk management in handling uncertainties issues. In the real world case, this can be seen with the case of Toyota where the failure of its technology performance and security issue (i.e. quality conformance) cost them badly. Recently, Toyota has had to recall millions of products due to accelerator pedal defects, which cost them nearly $1 billion lost and of course damaged their reputation as well (Page, 2010; Roberts, 2010). All these address the issue of complementary of quality and technology management, where it is necessary to get the right balance between the enhancement of technology and meeting the bottom line of quality and security conformance. In the bigger picture, this may lead to the study of sustainability in quality and technology management.

- This research has been illustrated using the Mozilla case, which is a networked organisation. A further investigation involving other companies from other settings (i.e. manufacturing industries) using the same process might be beneficial as comparison could then be made. The finding of this can further show the readiness of other industries to move into the characteristics of future context (i.e. the future works and coping with the changes in business environment).

- An investigation based on the proposed conceptual framework of principles, systems, tools and techniques, and focus could be further investigated into other areas, namely; project management, new product development (NPD) and marketing management.

- It is feasible to foresee that multiple areas are converging in multiple dimensions - there can be interesting research projects exploring such convergences in a similar manner, as the researcher has illustrated in this study of quality and technology management fields.

✎ Corporate Social Responsibility and Environmental will play major roles in business (Castka & Balzarova, 2008; Falck & Heblich, 2007; O'Connor & Meister, 2008; Robins, 2005) as well as proving to be the future of research. This may impact on quality and technology management and provide further opportunities for future work, specifically in the areas of continuous quality improvement, technology improvement, technology development, quality and technology leadership and standards (i.e. link to ISO 26000).

✎ In the area of climate change, specifically in limiting CO_2 emission for every vehicle, the European Commission's Consultation on implementation of the renewed strategy to reduce CO_2 emissions from passenger cars and Light-commercial Vehicles - has put an emphasis on the quality compliance, wherein the manufacturer of automobile from Korea, Japan, Europe and United State of America need to comply with a new standard - under low carbon vehicle partnership. In which, the manufacturers need to meet the reduction of carbon emission – Co_2 with less than 120g/km by the year of 2012. This leads to a new research on how the progressing of technology and quality compliances simultaneously working in achieving this aim. See UK's Low Carbon Vehicle Partnership (LowCVP) at http://www.lowcvp.org.uk/ and also Korea Automotive Manufacturers Association (KAMA) at http://www.kama.or.kr/eng/K_eng_main.jsp and Japan Automobile Manufacturers (JAMA) at http://www.jama-english.jp/index.html.

✎ The framework of 'focus, principles, systems, and tools and techniques can widely be used to other researches in a different contexts. As this framework is much similar to Pettigrew's 'context, content and process' (Pettitgrew, 1992), which has been used extensively in the area of quality and technology – e.g. (Munkvold, 2003; Sousa & Voss, 2002).

✎ A comparative study across the industries (i.e. Manufacturing, Oil & Gas, Construction and Plantation, Information Communication and Technology etc) can be done by using the framework of *Predicted changes in business and environment* as presented in **Table 5.2, Chapter 5** in page 95-96. This will uncover the answer of the readiness of each industry moving and tapping into the characteristics of future.

✎The propositions outlined in **Section 8.3, Chapter 8** in page 210 are presented as springboards for future empirical investigation. This can be tested into companies under the cluster of technologies based namely; (1) High technology, (2) Moderate technology, and (3) Low technology. Also, this can be further specific to those companies that underlined into networks based organisation and non-networks based organisation. Then, the comparison can be made.

✎ Also, this study can act as a base to conduct further explanatory research to establish the causal relationship between quality and technology management areas namely; continuous improvement, standards, leadership and partnership in organisations with open source networks-based business model and non-networks based. Then, the comparison study can be followed.

8.8 Critical Reflection

It has been well established that quality practices affects day-to-day organisational operations and business performance (Powell, 1995; Sousa & Voss, 2001). But despite the increased focus on Quality Management (QM) during the 1980s and 1990s, as well as the fact that quality became a central agenda point for top management, there have been relatively limited attempts on searching, reflecting and analyzing the QM philosophy and practices from a broader theoretical perspective. In fact, this is one of the major criticisms, which the quality movement often received from various theoreticians during the middle and the last part of the 1990s (Dahlgaard & Dahlgaard, 2003).

Further, Robert (2001) notes that conventional quality works best when firms are playing catch-up where they know pretty much the direction they need to go by observing those ahead of them. He adds that, traditionally, quality fit large Japanese manufacturing firms, which for most of the post-World War II period were playing catch-up. However, during the late 1980s, as the Japanese moved to the frontiers in many industries, they found it difficult to shift gears technology forward and they have fallen behind in many areas (Robert, 2001).

On the other hand, authors such as (Curry & Kenney, 1999) point out that the rapid transfer of technology and deregulations of markets are the main characteristics of the prevailing business environment. The speed at which firms develop and technology breakthrough and roll out new products has become an increasingly critical competitive issue. Such environments demand more attention of organisations be paid to the needs of customers to survive in the severe competitive environment (Baidoun, 2004). Therefore, technology may well become the ultimate tool for achieving a competitive advantage, the success that an enterprise has in using may depend on how well it adopts and integrates the other foundations (Khalil, 2000). Yet, these two fields; Quality Management and Technology Management in the literature work independently and addressed separately.

This scenario has been further underlined by Ettlie (1997) who claims that instead of studying quality as a separate issue in an organisation, a technology life-cycle approach is used to examine the quality and technology relationship. The results help explained why quality programs appear to get mixed reviews in surveys. As such, according to (Nasierowski, 2000), ISO/QS certification is often required to establish or keep cooperation links. Yet, quality and technology should be viewed in a broad perspective that encompasses social acceptance and understanding, infrastructure and economic conditions surrounding business operations, as well as legal and competitive pressures, which force companies to excel and be innovative (Nasierowski, 2000) and expanding utilisation of quality standards and excellence models into the field of technology management (Dolinšek, et al., 2007).

That said, in the author's opinion this sparks the light that there is a potential for Quality and Technology Management coming together in the future. Also, this study provides some light on some quality management literature, which claims that quality management has been stagnant without many breakthroughs. In short, the essence of this study is about identifying the areas of convergence (future commonalities/converging points) between the two fields (i.e. Quality Management and Technology Management), while looking from two perspectives and bringing a greater understanding in the network based context. However, the context of this research is not forced - presumed, but rather it emerged along the way of the study (i.e. as highlighted in **Section 5.6, Chapter 5** in pages 119-120).

In order to organise the content of quality and technology management study fitted into the box, the researcher has used the framework of ‘principles, systems, and tools and techniques’ – see (Dale, 1994) and further extended this framework to ‘focus, principles, systems, and tools and techniques’. As in the author’s opinion, it is appropriate to study each evolution of these fields by looking at how ‘focus, principles, systems, and tools and techniques’ have evolved, before predicting the future quality and technology management respectively. Thus, in doing so, the historical review allows the researcher to establish the pattern of quality and technology focus, principles, systems, and tools and techniques’ (i.e. as illustrated in **Table 4.1** – pg 65-68**, Table 4.2** – pg 85-88**, Table 5.3** – pg 98-100 and **Table 5.4** – pg 109-111). Although, at one time, the researcher also though that it also making sense to use Pettigrew’s framework, (Pettitgrew, 1992) ‘context, content and process’ which carry much similar function to ‘principles, systems, and tools and techniques’. However, the researcher believes it much easier for the reader to understand and follow the framework of ‘principles, systems, and tools and techniques’, as the terms of the framework itself comprehensively capturing the field of quality management and to a certain extent the field of technology management as well. This is in contrast to ‘context, content and process’ framework, which seem to be so general and perhaps better suit the business context.

Indeed, context is very important in this research. As the world is moving toward networks (i.e. network collaboration and open source innovation), network has become more and more important in daily life. This is a piece of work that is new in the emerging context. Also, this provides the initial insight on how quality and technology management may happen in the future context. However, in the early study which dates back to early 2008, the literature says very little about quality or technology in the context of the future (i.e. networks based organisation and open innovation). In fact, certain areas, like technology standards, are considered as an understudy topic (Leiponen, 2008). So, at that time, to predict the future of these two fields proved to be very difficult. Hence, as time goes by, there is some related research coming out with this kind of future study, and surprisingly, some of the early prediction regarding the future of these fields – the changing content of the principles - are truly in line (exactly the same) with literature – e.g. (Chowdhry, 2010; Ribiere & Tuggle, 2010; Waguespack & Fleming, 2009).

In terms of research design, the researcher has also identified that the study fits within the interpretivist paradigm. The researcher accepts the social constructionism basis, and believes that phenomena being researched are socially constructed. The researcher is also aware that there are some paradigms that have influenced this research process, such as hermeneutics and phenomenological. In turn, throughout the research process, the researcher opted for five key data collection methods (mixed methods) using: (1) Primary data from official company websites, (2) Primary data from 'hands-on trial observation', (3) Primary data from expert opinion survey via e-mail (electronic mail survey), (4) Primary data from face-to-face interview with scholar, and (5) Secondary data from documents (i.e. journal article and magazines).

Having done all these, in the author's opinion, the methodological approach of this research is very unique and robust in the sense that it is a kind of research is 'out of the box' - different from the typical/traditional kind of research in social science whereby most of the time researchers tend to use case study, questionnaires survey and face-to-face interviews as their approaches in collecting data/information. However, investigating a single organisation is futile, since the organisation will form part of a network. For example, there is less value for future research in continuous improvement based solely in a single company because in the future, it is about the improvement that comes from the network. The interactions and relationships throughout the network should be considered. Further, future research should not only focus on a specific issue (e.g. continuous improvement for product design) and neglect to other issues/factors around it. It should consider the entire system.

This means that the future researcher needs to understand the whole picture of the process internally and externally, as the future is not only about managing a specific problem in a single company, but what matters is how companies managing and dealing the wide resources of improvements and innovation across the networks with the architectural of participation and collaboration that come from all over the world (i.e. high involvement of communities of practice). Therefore, this will be the big challenge for researchers in the future.

In summary, as a result of this research, the new knowledge emerging from this research can be used by academic to shape their future works. Specifically, by looking at **multiple perspectives** –i.e. how to manage standards in the future? How the standards merge in quality and technology? Hence, in terms of practitioners, this study provides some guidelines about things such as, how they should manage standards, continuous improvement, leadership and partnerships in the network context. As mentioned earlier in **Section 8.4** - practical implication, this raises some interesting questions as follows:

1. Does the collaboration and partnerships in the network is equally and fairly benefit both parties? Are they willing to share their expertise (core competencies) with each other? Can this collaboration be extended to form partnerships with others in the network?
2. Are they developing the standards? If not why? What is the impact of this?
3. Are they managing continuous improvement across the network? How do they manage it?
4. Do they recognise leadership across the network and not just from one company? How do they manage it?

All of the above discussion suggest that the collaborators/partners need to think about how to manage the standards comprising of open technologies standards, codes of practice and standard for control, and to deal with the issues of managing leadership, continuous improvement and partnerships; internally and externally across the networks, which involves dealing with many actors – the interactions within themselves will be the major challenges. Therefore, all these provide the platform for the future research to uncover the knowledge and follow up with testing the concepts to empirical settings, which is equate to - from the concepts to the practises.

8.9 Personal reflection

In my early days doing my PhD, my supervisors keep on telling me that, “your writing needs to be: (1) Based on fact, (2) Grounded, and (3) Sensible…does it makes sense?”. Having practised that, this truly transforms me to be more sensible not just in the ways of doing research, but also generally as a person.

One of the good things doing PhD is that it provides me with lots of opportunities and a platform for me to share my works and ideas by attending conferences and workshops either internally or outwith the Strathclyde University. In doing so, I have received enormous suggestions and comments from the audiences, which were really helpful, as all these lead me to strengthen and explicitly demonstrate my works.

Table 8.7 and **Table 8.8** illustrate some of my publications and presentations throughout my PhD journey.

Table 8.7: Paper proceeding publications

Date Attended	Details
10 – 11 December 2008	*Social Innovation and Business Trends in the Future* for 5th International Conference on Innovation Management (ICIM) at Maastricht, Netherlands
6 – 8 September 2009	*Putting Technology Management in the future context* for 4th European Conference on Management of Technology (EUROMOT 2009)

Table 8.8: PhD research presentations

Date Attended	Details
17 May 2007	Research Colloquium
6 - 7 June 2007	3rd Scottish Doctoral Management Conference at St. Andrew University
25 – 26 June 2007	Ross Priory-Management Science Presentation
15 January 2008	Design Manufacture Engineering Management (DMEM) Research Presentation Day
7 March 2008	Management Science Presentation
26 - 27 June 2008	Management Science Presentation at Ross Priory
19 January 2010	Design Manufacture Engineering Management (DMEM) Research Presentation Day
28 - 29 January 2010	Management Science Ross Priory

To wrap up this, personally I also feel that PhD journey can be described as, '*no pain no gain'* but it is a truly amazing experience. For me, PhD is not just a training exercise, but it already becomes as part of mine...

When you walk through a storm
Hold your head up high
And don't be afraid of the dark

At the end of the storm
Is a golden sky
And the sweet silver song of the lark…
Source: You'll Never Walk Alone, by Richard Rogers and Oscar Hammerstein II

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Appendix A: Flow of thought process for quality management future context

Table 1 presents the matrix and each principle is discussed thereafter with regards to the drivers. The outcome of placing quality management in the future context is to highlight the principles of quality management that need to be reviewed and, where necessary, revised, incrementally or radically as appropriate.

Table 1: Matrix of drivers of future context and quality management principles

	Future Context															
Principles	(1) Web 1.0 to Web 2.0	(2) Ideas & Actions Originating from the Network rather than Internally	(3) Central Regulation to Self Regulation	(4) Contract to Trust	(5) Legal Regulation to Moral Regulation	(6) Increasing Transparency	(7) Proprietary to Open Source	(8) Copyright to Copyleft	(9) Increasing Emphasis on Innovation	(10) Bureaucracy to Netocracy	(11) Clear Organisation to Fuzzy Organisation Boundaries	(12) Increasing Emphasis on Community Opinion	(13) Increasing Emphasis on Continuous Learning	(14) Increasing Corporate Social & Environmental Responsibility	(15) Loyal Customer to Picky/Curious Customers	(16) Increasing Pace of Change
Continuous Quality Improvement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Conformance to Standard	X	X	X	X	X	X	X	X	X	X	-	X	X	X	-	X
Management Understanding	X	X	X	X	-	X	X	X	X	X	X	X	X	X	-	X
Customer Orientation	X	X	X	X	-	X	X	-	X	-	-	X	X	X	X	X
Quality Leadership	X	X	X	-	-	X	-	-	X	X	X	X	-	X	-	X
Quality Involvement	X	X	X	-	X	-	X	-	X	-	-	X	X	-	-	X
Quality Supplier Relationships	X	X	-	X	X	X	X	X	X	X	X	X	X	X	-	X
Process Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
System Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

(x) Identifies the potential impact of the corresponding future context on the corresponding principles of Quality Management

Flow of thought of Principle 1: Continuous Quality Improvement

The next continuous quality improvement could potentially incorporate network-wide continuous improvement, which has the following characteristics:

- Habitual
- Self managed
- Transparent
- Open source
- Participative
- Collaborative
- Trust
- Ideas and actions originated across network
- Community opinion
- Continuous learning
- Moral regulation
- Corporate Social and Environmental Responsibility

In the future, continuous quality improvement could potentially occur across the network (Hamel, 2007; Malone, 2004; Salina & Salina, 2007), where Web 2.0 could provide the platform for participation, collaboration and creativity, and allow more people to share ideas in a greater variety of ways (Grant, 2008; Gray, et al., 2008; Hamel, 2007; Hendler & Golbeck, 2008; Mason & Rennie, 2007; Needleman, 2007). Ideally, the more ideas that are shared, the more opportunity they have to grow and bear fruit.

In saying that, the researcher suggests that the next stage of continuous quality improvement could include '**Participative and Collaborative Improvement'**. Participative improvement in this context is a reflection of the members in a virtual organisation or practise group, who participate and communicate with each other via blogs and organisational websites (Grant, 2008; Gray, et al., 2008; Greaves & Mika, 2008; Hamel, 2007; Harinarayana & Raju, 2010; Ribiere & Tuggle, 2010; Shin, 2008). Initially, problems, ideas, quality solutions etc are the issues that need to be solved across this network (Ribiere & Tuggle, 2010; Vujovic & Ulhøi, 2008). The synergy of this network leads to collaborative improvements where particular ideas are put into action (Greaves & Mika, 2008; Shin, 2008). For example, members from the practice community share their comments, reviews and feedbacks on quality improvement with one another. One of the events occurring at present is 'Open Source Innovation' (Boudreau & Lakhani, 2009; Eisenmann, et al., 2008; Ribiere &

Tuggle, 2010; Ulhøi, 2004; Vujovic & Ulhøi, 2008), where the organisation invites outsiders to comment on their suggested design improvements. Thereby, continuous quality improvement could originate not only from the internal organisation (for example, through a suggestion scheme, like Genba Kaizen) but also across the network.

Further, such participative and collaborative improvement could occur in the context of relational trust (Berger, 2007; Crosno, et al., 2007; Smyth & Edkins, 2007). For example, a well-known free, open content, community-built encyclopaedia with thousands of articles – Wikipedia - is based on the idea that users can add an entry and edit the published information. To a certain degree, this open system reflects the level of trust that is pivotal within the relationship, as there is no contract to bind it.

Another example is the eBay community, where transactions between sellers and buyers is based on mutual trust. When the potential buyer wins the bid, he/she is obliged to pay for the item, once the method of payment has been agreed. Once the payment has been made, there is a promise that the item will to be sent to the buyer. Furthermore, eBay promotes the idea that the user is a contributor. Rather than central regulation, eBay use self-regulation (i.e. are self-managed). eBay allows its users to publish a review, leave comments and participate in the reputation evaluation that ranks both sellers and buyers. Inevitably, good comments will help build a good profile, which reflects trustworthiness and increases the seller's reputation. These two driving forces - trust and self-regulation - will potentially improve quality management for service-based companies in the virtual world.

It can be also argued that the idea of continuous quality improvement will no longer be bound by legal contracts. What matters now is transparency and the resulting increase in morality, as people are predisposed to make choices for the higher good (morality) including making improvements. Ideally, as transparency increases, there will be more trust.

"Transparency is a required condition for rebuilding trust and commitment in the relationship. The concept of transparency is linked to openness and is described as

being both a relational characteristic as well as an environmental condition for organizational processes. …Transparency was a critical condition for rebuilding trust" (Jahansoozi, 2006, p. 954).

Further, continuous quality improvement, in an open source context, creates more opportunities for developing and exploring new innovative ideas. The open source movement brings the ideas of participation, collaboration and creativity to our social structure. This waives the orthodox idea of proprietary and copyright and gives way to the new domain of copyleft. Ulhoi (2004) claims that the open source movement grew out of the principle of closed source (for example, the protection of intellectual rights and private investment was motivated by profit) - the latter is based on the commonly owned goods, as goods based on non-profit motives (Ulhøi, 2004).

Contrary to the closed-source innovation model, the problem of non-contributors or free riding is not a concern for open source innovators, since their personal gains are considerably higher than those of free riders (von Hippel & von Krogh, 2003). Free riders, it seems fair to assume, are unlikely either to acquire social recognition/status or experience any significant learning curve effect.

Psychological motives are based largely on the premises that intrinsic motivating factors exist which allow the participants to achieve a degree of personal satisfaction. If the concept 'the best idea to win' is within the network, then people will be motivated more by peer recognition and community prestige (reputation). This means that the continuous quality improvement movement is placing a greater emphasis on community opinion. However, some contributors have looked for external rewards by stressing the importance of peer recognition (communities of practice) (Johnson, 2002). He argues that such rewards can later be exported to the outside and translated into traditional monetary rewards.

As such, learning opportunities have been proposed as another important driving force (Lakhani & von Hippel, 2003) where learning by answering questions from users is a motivating factor for open source software developers. Continuous learning opportunities simultaneously provide a process of development for contributors and improvement for participators. This movement has brought what the researcher has called an increasing emphasis on continuous learning.

Borrowing the definition from Ulhoi (2004) which states that "*an innovation refers to any new or significantly improved change resulting from research and development, whether improving existing insights and/or knowledge, or improving the functionality, performance or other value to the user, and/or the exploitation of entrepreneurial opportunities'*", the new improvement in quality management in the open source environment will also foster innovation.

This network-based movement (Web 2.0 and open source) will reshape thinking on innovation, which is no longer a linear process, starting with invention and ending with market penetration for commercialisation. Now participation and collaboration are integral to innovation, which means that incremental innovation grows naturally out of the participation and collaboration required as part of networking.

It is suggested that with the evolution of Web 2.0, open source and social networking, customers have become more educated, especially those of the younger generation, and have become highly selective in choosing products. The continuous improvement via networking involves more customers, and the innovation of open source gives them the opportunity to satisfy their curiosity and find out more about new products whilst providing suggestions and comments to manufacturers to better meet their needs in the future.

The increase of corporate, social and environmental responsibility obliges the business sector to play a sensible yet not solely profit-orientated role (Baron, 2008; Cochran, 2007; Falck & Heblich, 2007; Heslin & Ochoa, 2008; Husted & Allen, 2007; Weber, 2008; Yoon, et al., 2006). This includes social and environmentally driven actions, where the business sector has been expected to go beyond its money-making and commercial activities to commit to the well-being of the community, thereby making the world a better place (Robins, 2005). This means that at any continuous improvement has to be aligned with social and environmental concerns. Castka and Balzarova (2008) insist that the new ISO 26000 should be closely aligned with ISO 14000, and requires organisations to develop their management systems around their social responsibility aspects and impacts.

On the other hand, barriers to information and knowledge are falling fast; which means that people in the network can access information quickly to make improvements. Blogs are a good example of this. The improvement via networking provides more cost efficiency, as the cost of networking is relatively cheap or could even be 'zero cost' compared to other mediums, such as telephone lines, consultancies, and other methods of communication (Corney, Torres-Sánchez , Jagadeesan , Lynn , & Regli, 2010; Pramatari, 2007; Ulhøi, 2004; Vujovic & Ulhøi, 2008). In short, this reflects that there is evidence of some action having taken place in the networks as the result of communication (i.e. participation and collaboration). New methods of communication (e.g. blog, wiki and forum) can greatly lower the cost of exchanging information and of providing the people with information. It is easy, fast and cheap to experiment.

As a result of all the above mentioned, the improvement will be more persistent and resilient with more ways of doing things, as the options continuously evolve (i.e. increase pace of change). Thus, architectures that are open, flat, malleable and non-hierarchical, make it possible for everyone to have a voice, and ensures that the tools of creativity are widely distributed (Hamel, 2007; Luo, Whitney, Baldwin, & Magee, 2009). Therefore, the speed of change and response can be faster as everyone learns and participates in quality improvement.

Flow of thought of Principle 2: Conformance to Standard

The next generation of the principle conformance to standard could be **conformance to network standard**, which is based on:

- Innovation
- Continuous learning
- Community opinion
- Self-regulation
- Knowledge sharing
- Corporate social and environmental responsibility

The researcher believes that the current quality conformance standard needs to be refined as the world is shifting towards the evolving trend of networking. In current quality management standards, the focus is on building around people's competencies. For example, the emphasis in training and development has been to build individuals' competency in performing their daily job. In the future, the focus will shift more on trust, morality (ethics) and transparency. As such, current quality standards may need to be refined to take into consideration the new elements of trust, self-regulation and transparency. For example, the Internet Engineering Task Force (IETF) is an open-technology community that develops standards for the Internet - the IETF community develops open technical standards. IETF processes are transparent and all resulting technology is freely available, where the IETF has no formal membership restrictions or voting rights, and any individual is free to propose new technical standards (Waguespack & Fleming, 2009). See also Internet Engineering Task Force (IETF) at http://www.ietf.org/.

In this case, it can be argued that current quality standards would not really work and be applicable in the future. That said, the researcher believes that there are three possible outcomes:-

i. Current quality standards will be refined, taking into consideration the new elements of trust, self-regulation and transparency.
ii. A new construct of quality standard will be released for networking standards, as the future quality standards could be tailored for networking standards. For example, formerly the release of ISO/TickIT for IT software and IT peripherals. The release of that quality standard is based on the nature of business/industry.
iii. Totally brand new standards will be released to replace the old ones. A new quality standard may need to be released for networking standards, in order to accommodate enormous business and social interaction in the net (e.g. internet and intranet). For example, ISO/TS 16949 has replaced QS 9000 and QS 9000 has become obsolete.

The success story of eBay makes us realise that the idea of current quality standardisation is not always the best one to apply. For example, the ISO 9000 series and ISO 14000 series place the focus on competencies, where the idea is to build on the core competencies via training. But now, other drivers will come into play, such as trust (Berger, 2007; Porter & Donthu, 2008) and self-regulation (Temponi, 2005; Vujovic & Ulhøi, 2008), where the user is both a contributor and participator, are the critical success factors. Ideally, this means that standards could be self-regulated (i.e. following eBay business model and IETF model).

In short, quality management standards in the future - the so-called 'conformance to networking standard' - also need to consider trust and self-regulation within the standards. The standards provide support by emphasising trust where the ideas are not based on legal contracts or closely aligned to procedures and regulations, but have much greater transparency and openness. As such, the introduction of reputation systems and business network models (profile based) could be introduced to help people choose high quality providers, where specific quality standards would not be relevant.

On the other hand, it is clear that new quality standards for networking are needed (for example TickIT for software and IT peripherals). For example, the transaction process in eBay can be put into the formal process and procedures, and this becomes the standard for the business-networking model. That said, the future quality standards could be tailored for networking standards, where there is a need to recognise the issues of leadership (i.e. managing coaching leadership), partnership, collaboration, continuous improvement, privacy, and security concerns in a networks context.

As a result of this, a new standard of conformance is required that deals with the demands of the latest technological environment in order to accommodate large-scale business and social interaction on the net (e.g. internet and intranet). Also, with its underlying culture of sharing and combining new ideas and know-how, it can provide a platform for innovators with new ideas. Ideally, the new standard can be shared, and commented on the web, guiding the contributor and participator to respond as part of the new process of learning and enhancing knowledge (Nadvi, 2008; Waguespack & Fleming, 2009). See also Internet Engineering Task Force (IETF) at http://www.ietf.org/.

As such, a practice group in the industry can have a debate and open argument regarding the standard, the clauses, the sub clauses, things to be improved, and things that should be obsolete. Of course, in the network environment, only the best idea will win (e.g. on a meritocracy basis). This suggests that the best idea will be recognised by the members of the group communities.

This will also bring recognition and prestige to the people in the community. Initially, this may increase the pace of response and change as new standards are discussed, commented on, and reviewed by the different practice groups as part of the improvement process (i.e. following the Internet Engineering Task Force (IETF) model). Further, a new standard should consider the evolution of corporate social and environmental responsibility. It is a possibility for this element in the ISO 26000 to be merged into the new networking standards as well.

Flow of thought of Principle 3: Management Understanding

The principle of management understanding in the future could be based on:

- Self-organising teams from across enterprise, in which trust, openness and transparency becomes the managerial philosophy/approach
- People operating as innovative problem-solvers
- Loosening the hierarchy, placing greater emphasis on harnessing democracy and coordinating activities

Looking at current business trends in companies such as eBay, it is clear that business models are shifting to focus on relational trust (Berger, 2007; Crosno, et al., 2007; Smyth & Edkins, 2007). Trust is the element that bonds the seller to the buyer on their sites. More often, this is supported by incremental transparency, from closed to open with relation to intellectual property (i.e. open content). Openness will be the sticking point for companies as to how far the organisation is willing to share information and cede knowledge, both within and outwith the organisation (de Laat, 2005; M´alovics, Csig´en´e, & Kraus, 2007; Ribiere & Tuggle, 2010; Vujovic & Ulhøi, 2008). It is fair to say that there is a move towards a flat organisational structure with transparency and controlled real time data access to all levels (Pralahad & Krishnan, 2008, p. 170), as moving from rigid organisational charts to fluid operations models and project teams (Hamel, 2007; LaRoche, 2009). This also brings forward a view of self-organising teams from across the enterprise in which trust, openness and transparency becomes the managerial philosophy/approach for successful companies in the future. As such, management understanding could look at Web 2.0 as the business model to follow, as this movement mainly promotes participation, collaboration and self-regulation (Boudreau & Lakhani, 2009; Harinarayana & Raju, 2010; Vujovic & Ulhøi, 2008).

Future innovation in the organisation will not just be a linear process. For example, former innovation was a process of thinking, from invention to commercialisation. The current context of innovation in the organisation is best described as a way of thinking that is focused beyond the present to the future, where everyone becomes a participator and contributes towards achieving that vision. Ideally, this stimulates more innovators and creative thinkers to commit to the success of the organisation. New innovative ideas will improve quality management, and move from quality improvement to quality innovation. The researcher considers 'quality innovation' as a new way of thinking. This highlights the second stage of thinking, where quality is not just for improvement alone, but can transform into quality innovation or improvement. This involves people operating as innovative problem-solvers (Terwiesch & Xu, 2008).

Future organisations will demand a quick decision in the dissemination of information. As a result of this, the structure of the organisation will not just be based on formal designation and a rigid hierarchical structure (span of control), but the new management structure will reflect the transition to flat, flexible and fuzzy boundaries (i.e. from bureaucracy to netocracy) (Hamel, 2007; Luo, et al., 2009).

This new structure is expected to suit the richness of information within the organisational boundaries. The transition from a bureaucracy to a netocracy structure, reflects the idea of moving from a clear organisation to a fuzzy organisational boundaries. This leads to a situation where the only hierarchies are 'natural hierarchy' (Hamel, 2007). For example, Linux was written by a loosely coordinated hierarchy consisting of thousands of volunteer programmers across the world (open content). An even looser hierarchy exists for Wikipedia creating an Encyclopedia (Malone, 2004, p. 43). Ideally, this helps the business become responsive and enhance its operational pace of change.

Quality responsibility is no longer an obligation of the quality assurance department alone. People in the organisation will become multi-skilled and enriched with knowledge and therefore people from outside the quality department can contribute to the enhancement of quality management. Thereby, the future management understanding of quality management will provide more learning opportunities for an individual in the team and the organisation. As a result, the staffs are given more space and freedom for their development. This also becomes the platform for the staff to increase and equip their knowledge.

It is also believed that corporate social responsibility (CSR) will be the focus of the management agenda. The growth of attention to CSR in business indicates the development of these matters. The focus of Quality Management will also need to place emphasis on stakeholder responsibility as this is aligned with the latest ISO 26000 (recent Quality standard for corporate social responsibility) dealing with the responsibility of stakeholders for social and environmental concerns.

Flow of thought of Principle 4: Customer Orientation

The principle of customer orientation in the future could be based on:

- Customer as part of the network
- Continuous customer engagement and reengagement in the form of collaboration, innovation and learning with the customer as an integral part of the network

It is anticipated that customer orientation will increasingly involve bi-lateral relationships (Grunert, et al., 2008; Jayaram, Vickery, & Droge, 2008; Kaynak & Hartley, 2008; Ribiere & Tuggle, 2010). The unilateral relationship involved one-way traffic, where producers are the actors who meet and exceed the need of customers without getting much response or review from them.

Now, the idea is to let the customer take part in the process of improving the product. The customer is therefore involved in the process from the early design of the product to the after sales service (Jayaram, et al., 2008; Ribiere & Tuggle, 2010). The voice of the customer will predetermine the product or services provided. Web 2.0 and open source innovation are an example of a platform that connects more people; specifically, by communicating through blogs. This open source community is an evolving trend that gives opportunities to customers to participate and give comments to producers (Ribiere & Tuggle, 2010; Vujovic & Ulhøi, 2008). As such, Web 2.0 promotes elements of trust and self-regulation by inviting customers to become sellers and buyers at the same time (e.g. eBay and Auto Trader). Thus, customers are involved in the business directly and truly become a part of the business model.

The social movement puts forward the view that customers should participate actively in the product and services development, and share their thoughts and reviews of the products - customers provide a wide variety of skills and motivation levels, which promote dialogue with producers/manufacturers and among consumers. This two-way communication is believed to increase transparency in the relationship between producers, suppliers and customers. In addition, this movement provides a platform for promoting new innovations and fostering new knowledge.

This reflects the situation where continuous customer engagement and re-engagement in the form of collaboration, innovation and learning with the customer as an integral part of the network. This view is in line with (Prahalad & Krishnan, 2008) who claims that customers are increasingly a source of competence. An informed and active customer base is emerging. Customers are willing to engage and co-create their personalised experiences (Prahalad & Krishnan, 2008, p.235).

Thus, this creates a learning process for the producers to learn from customers' feedback (Ulhøi, 2004). In the meantime, it also provides opportunities for the producers and customers to increase their knowledge literacy. As a result, customers become well informed and demand higher and better quality products and services.

The advantage of this movement is that the quality of the product will be improved and amended faster through the pooling and development of ideas and solutions. Therefore, this is likely to increase the pace of change and the response from the producers and service providers. Occasionally, this may help to mitigate the issues arising from customer complaints, and reduce the time of response to solution.

Overall, it may be fair to say that producers will enjoy the benefit of the evolving Web 2.0 as they gain the trust of their customers (as the customer becomes the contributor and participator in the web). There is also a need for more transparency in dealing with their relations with customers to fully benefit from this movement.

Inevitably, the next generation of quality standards might be needed to focus on customer demands in relation to corporate social and environmental responsibility. This would help producers enhance their reputation by making a commitment to environmental concerns and being responsible for corporate matters as producers who both listen to and take account of community opinion.

Flow of thought of Principle 5: Quality Leadership

The principle of quality leadership in the future may be based on:

- Innovative leadership mindset
- Complex system of leadership and coaching

Future leadership is anticipated to be closely related to issues of corporate social and environmental responsibility. This matches with the increased focus on compliance with environmental and corporate social standards (e.g. ISO 14000 and ISO 26000) (Baron, 2008; Husted & Allen, 2007).

Another issue will be the focus on innovation, where the leader needs to demonstrate that innovation is part of his mindset (Hamel, 2007; Jong & Hartog, 2007). Of course, creativity and innovative thinking will have to be promoted in the organisation in order to create more innovators. As such, the next agenda for the quality leadership thinking line will be to enhance reputation and peer recognition through an emphasis on community opinion (Boudreau & Lakhani, 2009; Hamel, 2007; Ramaswamy, 2009; Ulhøi, 2004; Weaver, Pifer, & Colbeck, 2009).

This may cause the leader to become the role model and quality leadership champion. Therefore, the researcher suggests the next transition of quality leadership can be called '**Innovative leadership mindset with a complex system of leadership and coaching'**. Leadership would not just come from within the organisation, as inspiration will also come from across the network as part of the coaching process.

'A swarm of bees and a school of fish leadership' Malone (2004) are the metaphors that can describe coaching leadership on the network. As more people seek faster information and solutions through the network, this leads to the emerging coaching leadership, shifting from power based on position to power based on respect, trust and expertise (Terwiesch & Xu, 2008; Waguespack & Fleming, 2009).

More specifically, this metaphor reveals the leader of the network (virtual group of practices/virtual communities) where he/she is referred to by others without having the trappings of power. This is a movement to a situation where there is no real leader. Everyone can participate and collaborate with each other and the position of leader can be rotated amongst them. This could truly happen if all the members have more or less the same capabilities in the performance of their work. Therefore, leadership in Quality Management needs to consider shifting from bureaucratic to flat structure management. This would help conceptualisation and faster decision-making by reducing unnecessary hurdles (red tape) in an organisation. For example, quality issues, such as customer complaints, can be channelled to the Quality Manager directly, or to the person in charge, so that faster action can be taken.

Ideally, a fuzzy organisation promotes self-regulation where the workers are given more freedom in the performance of their tasks, and enables ideas to be competed on an equal footing. Quality leadership will be more transparent and characterised by a high degree of openness and sharing, where the information and decision-making processes will be on view to the public. Also, there will be quality leadership transition from command and control to coordinate and cultivate (Hamel, 2007; Heslin & Ochoa, 2008; Porter & Donthu, 2008). Cultivate means taking advantage of people’s true intelligence and creativity, which are the most critical capabilities of successful businesses.

As such, quality leadership will move from narrow, constraining job descriptions to a dynamic, tradable portfolio of operational, project and leadership roles that tap into people's full potential. Power is granted from below, where the authority is fluid and contingent or value-added and where almost everything is decentralised (Hamel, 2007). From reactive top-down assignments to proactive bottom-up initiatives by self-organising teams. Hence, this leads to an increase in the pace of change and the interactions between the workers and management.

In short, this suggest that the principle of quality leadership in the future may be based on ‘swarming’ – the coaching leadership in network (Malone, 2004) and innovative leadership mindsets in the complex system of leadership and coaching. The leader will be more empowered, democratic, and decisions are more likely to be peer-based.

Flow of thought of Principle 6: Quality Involvement

The future principle of involvement would be based on:

- Virtual involvement
- More dynamic members sharing ideas, experience and knowledge

In general, involvement in Quality Management includes employees at all levels of the organisation who can fully participate and employ all their skills to make the organisation successful (Sun, Zhao, & Yau, 2009). In the future, the researcher suggests that involvement in Quality Management will develop across the network and include sub contractors, customers and others. It is no longer just based internally within the organisation, but throughout the network. Therefore, the next quality involvement could include '**virtual involvement'**.

As former employees' involvement is within the organisational context, the new transition could be across the network and connect with a wide range of people. Web 2.0 can play a part by providing the platform, such as blogs as a medium for this virtual involvement. For example, virtual involvement could involve connecting internal employees to external employees in another branch in a different part of the world (for example from Motorola in Penang, Malaysia, to Motorola in India). This reflects that involvement comes both internally and from beyond the boundaries of an organisation, with more dynamic members sharing ideas, experience and knowledge.

It is fair to say that the involvement itself is the foundation for open source. The involvement in the context of open source innovation (open sharing for open source community) is more holistic, which involves the employees, suppliers and customers (Boudreau & Lakhani, 2009; Corney, et al., 2010; Ribiere & Tuggle, 2010; Ulhøi, 2004; Vujovic & Ulhøi, 2008). Therefore, there is a greater dynamic for members to change through their sharing of ideas, experience and knowledge. It is anticipated that this will be the next trend in Quality Management with ideas to increase the emphasis on innovation and improvement for quality.

It is also believed that the future context of involvement will not take place through force or demands from employers, but rather through a willingness for it to become the norm (Hamel, 2007). It is based on morality and employees participating in an ethical manner, in order to increase their own knowledge, and for the greater benefit of the organisation. Of course, more involvement provides more learning opportunities and also greatly enhances the knowledge literacy of participants.

Thus, this moves the idea from employees as cogs in a machine, offshored to the lowest bidder, to creative, empowered team members. Employees shift from a confined/narrow job description to providing services/roles for an evolving portfolio of initiatives, which can be more proactive, instead of simply reactive to the superior. This shift will increase voluntary commitments (as opposed to forced assignments) and encourage more efficient group time utilisation via collaborative spaces. In short, this embracing of values generates self-guidance, self-policing, and peer responsibility for keeping one another aligned with the core set of principles, reducing the need for rules and thus helping people feel autonomous. Rather than feeling forced into conformity, employees feel that they are wilful actors making their own choices based on principles they can support (Hamel, 2007; Temponi, 2005).

As such, the involvement of employees can be inspired through the movement of self-regulation where employees build up self-organising teams for quality improvement. In saying that, the researcher believes that self-regulation is fundamental to the success of the self-organising team. Where self-regulation can be inserted into the involvement principle, it will then help to fast track the pace of change and response to future solutions. In addition, **virtual involvement** can develop and increase community prestige. For example, growing academic communities (the IAMOT community and EUROMA community), where the future quality group of practice can learn from other virtual communities or groups of practice, and adapt to enhance their own performance and prestige.

Flow of thought of Principle 7: Quality Supplier Relationship

The next generation of supplier relationships could be based on **supplier involvement in open source improvement activities throughout the network.**

It is a belief that the principle of involvement would constitute the foundation for the next supplier relationship principle. The relationship is shifting from a supplier relationship (Carr, et al., 2008; Fink, James, Hatten, & Bakstran, 2008; Kaynak & Hartley, 2008) to **supplier involvement (supplier partnering)** (Jayaram, et al., 2008; Kuei, Madu, & Lin, 2001; Li & Vanhaverbeke, 2009; Sheu, Lee, & Niehoff, 2006) **in open source improvement activities throughout the network** (Grunert, et al., 2008). This may happen as Web 2.0 and open source, specifically open source innovation, provide the platform for suppliers to be more actively involved in the company's activities, such as giving comments and suggestions about product design and materials for new product development, particularly in the early stages.

Ideally, this provides direct two-way communication between the supplier and producers to improve and increase their innovation of products or services provided through the network. Formerly, the issues in supplier relationships is about make or buy (outsourcing) decisions (Moses, 2009), but now the relationship is shifting to open source innovation, where the pivotal idea is for the supplier to be more involved in the company's activities (Boudreau & Lakhani, 2009; Corney, et al., 2010; Ribiere & Tuggle, 2010; Ulhøi, 2004; Vujovic & Ulhøi, 2008). To a certain extent, supplier/partnerships are competing and complementary (coopetition) with producers and each other at the same time (Casadesus-Masanell, Nalebuff, & Yoffie, 2007; Chen, 2008).

In addition, this movement brings in the element of trust and transparency that is needed to enhance relationships. As the supplier becomes well informed about the materials, customer specification, quality work instruction etc, this may lead to better supplier relationships (Hamel, 2007; Kaynak & Hartley, 2008). As supplier involvement becomes the norm, the two-way relationship happens regularly and is not just a one-off meeting. Crucially, miscommunication and misinterpretation can be reduced. In line with these ideas, Prahalad and Krishnan (2008, p. 183) put forward the view that future supplier relations will involve facilitating collaboration across the firm and its partners and thus identifying new opportunities for process innovation and customer value.

Ideally, this will increase the pace of change and response between the producers and suppliers. For example, if the customer requests change in relation to product specification, the changes can be expedited (quickly). As a result, this relationship creates learning opportunities and also enhances knowledge literacy between the producers and suppliers. Therefore, it is fair to say that, in the future, the principle of a quality supplier relationship would be based on collaboration in supplier relationship/collaborative networks, where suppliers and customers integrate their business model while competing and complementing each other. This makes it possible with the use of ICT platforms; i.e. Web 2.0, which shifts the ideas and actions originating from networks, netocracy-based and fuzzy organisation. In relation, there will be more need to establish trust, transparency and copyleft, moral regulation, and open source innovation. Other drivers will also come into play, such as increasing the emphasis on communities of practice, and continuing the focus on corporate social and environmental responsibility.

Flow of thought of Principle 8: Process Management

The future principle of process management would be based on:

- Processes extended beyond organisational boundaries
- Extended processes are managed as an integrated system across network

In general, every operational activity is perceived as a process in Quality Management. The researcher proposes that the future context of process management in Quality Management is highly influenced by the developing movement of the networking era. The researcher suggests that this future principle of process management can be referred to as '**Processes extend beyond organisational boundaries where extended processes are managed as an integrated system across network**'.

Ideally, such thinking consists in the idea that every single quality process is managed throughout an integrated system (for example, a production system), where the process of improvement can come from across the network. For example, the development of Web 2.0 has given opportunities for process management, not just to build up internally but to be built across the network as well, as Web 2.0 provides the platform for personal blogs and the evolving open source community, and other group practices. Also, through networks, this brings a shift towards netocracy and fuzzy organisational boundaries in the principle of process management.

Ideally, this can also increase innovation through access to the larger pool of innovators across the network (Greaves & Mika, 2008; Mason & Rennie, 2007; Ribiere & Tuggle, 2010; Terwiesch & Xu, 2008; Vujovic & Ulhøi, 2008). This means that the processes extend beyond organisational boundaries and where managing external (outside) processes become the major challenge (Boudreau & Lakhani, 2009). Other drivers may also come into play, such as the increasing emphasis on customers to be part of the process management, along with concerns of corporate social and environmental responsibility.

As such, improved process management across the network would focus on process improvement, where the free rider or imitation would not be the concern (Ulhøi, 2004; Vujovic & Ulhøi, 2008) - being more transparent, from closed to open intellectual properties (Baldwin & Woodard, 2008; Cheliotis, 2009). Further, improvements in the processes are geared towards sharing the benefit of the goods with the public (copyleft), instead of the former copyright approach.

This ambitious idea does well in the environment in that it moves from a focus on legal aspects to moral considerations. Moral in this context means that people are willing to do and share things for the beneficial good (Falck & Heblich, 2007). This is in line with the idiom, ‘Doing the right things, right’ and consists of the willingness to perform tasks without being instructed, and where trust becomes the main driver for every player to contribute and share their thoughts on the quality process.

Process management in the context of self-regulation means that each quality activity is a process that can be self-organised by the quality members. Inevitably, every person can take part in process improvement, as the process improvement obtains solutions from the greater pool of sources, which may also include the expert across the network. For example, DuPont's R&D staff, who are trained in Six Sigma, help to improve processes by removing cost from supply chains, attacking slow-moving inventory, and streamlining innovation processes across their operation (Chowdhry, 2010).

In general, this leads to an increased success in the implementation of new processes and a much-reduced degree of failure, as more people can gel together. This provides a better learning opportunity, and improvements in the degree of information being shared to enhance knowledge (Ulhøi, 2004; Vujovic & Ulhøi, 2008). Eventually, every new idea that improves the process may contribute to knowledge literacy. Significantly, this may help to speed up the pace of change and the response to problems, and provide future solutions for managing quality processes.

In the networking community, they may select the best idea to improve the process. Then, if the idea is proven, the originator of that particular idea may get the recognition from his/her peers, consequently improving his profile and reputation. Viewing the process from a psychological perspective, this enhances individual satisfaction.

Flow of thought of Principle 9: System Management

The future principle of system management would be based on:

- Understanding complex causalities, including people, across the network extended processes.

Formerly, in the early era, system management refers to understanding isolated cause and effects in product quality. Now, in a system view, quality management looks at system management as a whole (i.e. quality system management in an organisation). This can be perceived as understanding complex causalities, including human factors, in that particular system. The researcher proposes that, in the future, the principle of system management may be shifting to a better **understanding of complex causalities, including people, across the network extended processes.**

In general, processes create the structure of the system, where processes as a whole are interrelated and generate the system. Therefore, the researcher considers that the processes are managed as an integrated system, so the principle of process management becomes the foundation for future changes of system management. Putting the principle of system management into the future context, it is a belief that system management as a whole becomes much more complex as the interrelated processes (e.g. internal and external processes) are embedded in the system, which extend beyond the internal boundaries of the organisation.

Appendix B: Flow of thought process for technology management in future context

Table 1 presents the matrix and each principle is discussed thereafter with regards to the drivers. The outcome of placing technology management in the future context is to highlight the principles of technology management that need to be reviewed and where necessary revised, incrementally or radically as appropriate. **Table 1** also shows how the predicted future changes may impact on the current technology management principles.

Table 1: Matrix of drivers of future context and technology management principles

	Future Context															
Principles	(1) Web 1.0 to Web 2.0	(2) Ideas & Actions Originating from the Network rather than Internally	(3) Central Regulation to Self Regulation	(4) Contract to Trust	(5) Legal Regulation to Moral Regulation	(6) Increasing Transparency	(7) Proprietary to Open Source	(8) Copyright to Copyleft	(9) Increasing Emphasis on Innovation	(10) Bureaucracy to Netocracy	(11) Clear Organisation to Fuzzy Organisation Boundaries	(12) Increasing Emphasis on Community Opinion	(13) Increasing Emphasis on Continuous Learning	(14) Increasing Corporate Social & Environmental Responsibility	(15) Loyal Customer to Picky/Curious Customers	(16) Increasing Pace of Change
Technology Development	X	X	-	-	X	X	X	X	X	-	-	X	X	X	X	X
Technology Improvement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Technology Leadership	X	X	X	-	-	X	X	X	X	X	X	X	-	X	X	X
Technology Partnerships / Supplier Participation	X	X	-	X	X	X	X	X	X	X	X	X	X	X	-	X
Technology Pioneering	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X
Technological Integration	X	X	-	X	-	X	X	X	X	-	X	X	X	X	-	X
Technological Value	X	X	-	-	X	X	X	X	X	X	-	X	-	-	X	-
Technology Standards	X	X	X	X	-	X	X	X	X	X	-	X	X	X	-	X

(x) Identifies the potential impact of the corresponding future context on the corresponding current technology management principles

Flow of thought of Principle 1: Technology Development

The researcher suggests that the next technological development will generate new opportunities for development and strategies in harnessing millions of people over the network (Hamel, 2007; Hoving, 2007; Nousala, Ifandoudas, Terziovski, & Chapman, 2008), in order to co-create products through peer production, engaging communities of practice and open source movement, as this leads to the development of technology that comes from the process of synergy via collaboration (Boudreau & Lakhani, 2009; Grunert, et al., 2008; Magnusson & Johansson, 2008; Vujovic & Ulhøi, 2008).

This advances the view that in the future, development of technology could be conducted throughout the network where Web 2.0 (social networking sites) would represent the pillar for technological development in terms of providing a platform for participation, collaboration and creativity across the network, as future technological development will be closely linked with collaboration and partnering across a wide network.

Hence, the development of new technology is not solely about internal R&D, but it may come from outwith the organisations – 'globalised R&D'(Chowdhry, 2010; Alexander Gerybadze & Reger, 1999). This means that the ideas and actions originate across the network rather than just internally. Thus, there will be more third parties contributing to the development of new technologies. This will allow organisational resources to flow more easily towards opportunities, as well as address problems at an early stage (Hamel, 2007; O'Hara-Devereaux, 2010). To a certain extent, this will result in cost savings and reduce development failure (Boudreau & Lakhani, 2009; Hamel, 2007).

However, new developments in technology also need to consider moral regulations as well as legal regulations. For example, those aspects of technological disaster and technological acceptance in relation to human cloning. In terms of transparency, the increase in clarity (i.e. from a closed to an open source) reflects the development of new technology which links to openness and technology acceptance. The more that ideas are open and shared, the more variety of ideas can be gathered and new developments may progress.

As such, the development of technology throughout the network can be linked to technology standards, then public standards (Pramatari, 2007; Rysman & Simcoe, 2008; Waguespack & Fleming, 2009). This gives the public more freedom to share and access technology, which inspires developments in new technology. Ideally, copyleft links to technological standards and public standards to inspire new developments in technology. In terms of innovation, the focus of new technological developments would take the form of non technical/technological innovation via network innovation (e.g. social networking sites). To a certain degree, this reflects the increasing emphasis on community opinion within the networks. For example, from peer-to-peer blogs and Intranet 2.0. This leads to new developments in technology and supports other developments in network technology. Consequently, this driving force of continuous learning will drive more learning opportunities to replace existing technology or current technology platforms**.** On top of that, new technological developments need to consider the demands of corporate social environmental issues, with regards to new developments in technology for products or services.

A new technological development also needs to consider more informed customers. For instance, more selective customers demand better technology in products or services. The improvement via networking involves more customers, and the innovation in technology development gives them the opportunity to satisfy their curiosity and find out more about new products whilst providing suggestions and comments to the manufacturer to better meet their needs in the future. So, the development of new technology will be more customised and tailored for the customer, where customer interaction and feedback is at the forefront (Chowdhry, 2010; Jayaram, et al., 2008; Ribiere & Tuggle, 2010; Shaw, 2002).

Occasionally, there would be an increased injection of pace in relation to change. The pace of change in terms of S-curve changes and product life cycle from one phase to another could be quicker in conjunction with the development of new technology.

Flow of thought of Principle 2: Technology Improvement

The principle of technology improvement in the future could involve **networking wide technology improvement**, which has the following characteristics:-

- Web 2.0
- Self managed
- Trust
- Moral regulation
- Transparency
- Open source and Copyleft
- Participative
- Collaborative
- Innovation
- Originated across network
- Community Opinion
- Knowledge Sharing
- Corporate Social and Environmental Responsibility

The transition from Web 1.0 to Web 2.0 impacts on technology improvement in terms of process improvement. For instance, technology can be improved mainly via the network from ideas to actions. This can be justified as people are willing to comment and put honest reviews in order to improve existing technology, and therefore the ideas and actions are originating from the network rather than internally (Ribiere & Tuggle, 2010; Vujovic & Ulhøi, 2008). With Web 2.0 as the platform behind this movement, more global players throughout the networks can share and respond, leading to the transformation of ideas into actions. Nevertheless, Web 2.0 itself promotes the element of self-recognition, which makes people become more independent and self-managed in performing their job. Ideally, people become more responsive and willing to think and react in innovative ways and become more creative (i.e. self-regulation). This leads to improvements in technology, which is persistent and resilient, and affording more ways of doing things, as the options continuously evolve (i.e. through the participation and collaboration amongst the communities of practice) (Greaves & Mika, 2008; Shin, 2008; Weaver, et al., 2009).

The transition from relational contract to relational trust allows trust to become the unconditional element for technology improvement, specifically in the network.

Most of the business, project and improvement in the network needs to build upon trust, as people do not even see each other or have any contact beforehand (e.g. face-to-face interaction). This reflects the principle that the greater the transparency, the deeper the trust will be. As such, the improvement is not based on the primary basis of legal regulation, but is more prone to moral regulations, where people are willing to refine existing technology. This would potentially increase transparency, as people are more open to share new ideas, explore, develop and materialise them.

Open source and copyleft movements can possibly affect technology improvement. To a certain extent, technological improvement, especially in terms of intellectual property, would bring the potential of more new ideas and invention, which can be shared in greater amounts. This includes the participation of people (actively giving ideas and comments) and reviewing current ideas, products and services, which ideally will enhance breakthroughs in new technology (i.e. increasing leap of innovation) in the market. Another element is collaboration, where firms in the industry can gel together to produce new technology improvements, either in the sense of the technology improvement process or end-to-end product improvement. As a result of these, copyleft movement can inspire more young companies and small budget companies to be more innovative and competitive in order to improve existing technology in the market. Of course, this is a relatively cheaper strategy than producing masterpieces from typical research and development.

Further, it could be argued that netocracy could play an important role for technological improvements in the future. Eliminating red tape and introducing a meritocracy will be supporting elements for driving forward such innovations. Indeed, in building new products and services, firms will also need to take into account their corporate social and environmental responsibility. This includes placing an emphasis on community opinion (communities of practice), as the brain of the networks which lead to peer recognition and reputation building in the industry. The idea is not based solely on finance, but will also focus on showing responsibility for the greater good of society. Customers have been well fed with information and knowledge about the latest trends in technology around the world. Information about products or services can be easily accessed from websites, so, as a consequence, customers are likely to become more choosy and demanding. However, on a positive note, the customer becomes willing to share their thoughts about product improvement, and demand what is right for themselves. As the result, this also contributes to new improvements in technology.

In terms of organisational structure, in the future, the transition from clear organisation to fuzzy organisation boundaries, gives more opportunities for people to be integrated into project based teams (i.e. cross-functional) and not be static to their job descriptive/function. Each function can be more flexible and work together. Job enrichment will be the idea with the greater use of Web 2.0 and the open source innovation concept, so technology could be improved in a faster time, as people within the organisation of each department and function can share their opinions, suggestions and take action for the improvement of product or services that they offer. As the network becomes the platform, everyone can enjoy and take benefit from self-improvement and self-learning. This becomes good practice and a learning curve for everyone to participate, collaborate, review and revise each other's ideas and put the ideas into practice. As a result, this leads to an increasing pace of change and response in the improvement of technology. Consequently, this also creates an environment of continuous learning within and outwith the organisation.

Similarly, Boudreau and Lakhani (2009) suggest that future technology improvement will be via external innovation, with multiple parallel paths to solve an innovation problem. In both markets and communities, external innovators will explore innovation landscapes that are often unknown and unexpected by the organisation. A high-performing solution often comes by this type of exploration. External innovation also appears to be more cost-effective, because the cost of failure is typically not borne by the host organisation. If an external innovator fails in its attempt to solve an innovation problem, then it alone bears the costs (and benefits of learning) from that attempt (Boudreau & Lakhani, 2009). Also, external innovation appears to achieve fast solutions that arrive quite quickly and can often exceed the capacity of the seeker (Boudreau & Lakhani, 2009).

Flow of thought of Principle 3: Technology Leadership

The principle of leadership in the future could be based on:

- Handling technology development, management, scalability and openness issues
- How to design, build, launch, market, support and maintain products and services, and to be effective in working within and directing communities of employees, users and partners in accomplishing large scale outcomes.

The transition from Web 1.0 to Web 2.0 brings participative, collaborative and sharing to be the foci. The architecture of Web 2.0 movement provides the platform for technology direction, where the ideas and actions with regards to leadership in technology areas not only comes from inside the organisation but also across the networks. Community leadership roles may be granted based on how active an individual is within the community as well as the quality and nature of his or her contributions (Waguespack & Fleming, 2009).

Further, ‘a swarm of bees and a school of fish leadership’ are metaphors that can describe coaching leadership in networks (Malone, 2004). As more people seek faster information and solutions through networks, this leads inevitably to the emergence of coaching leadership. This results in network leaders – and the emergence of a communities leader – who is referred to by others without having the trappings of power (Hamel, 2007; Waguespack & Fleming, 2009). This would suggest we are moving to a situation where there is no real leader. Put another way, such a system would mean that everyone could participate and collaborate with each other, and the position of leader could be rotated amongst participants. This could happen if all members have more or less the same capabilities in the performance of their work.

Thus, technology leadership in the future is likely to focus on harnessing the technology, and where the leadership challenge needs to get the right technology to work towards providing business value (Hoving, 2007). The direction of future technology would blend these together with respect to political, economic, social, technological, legal and environmental (PESTLE) aspects outwith the organisation.

In addition, future technology leadership will be about handling technology development, where management, scalability and openness are the issues. To a certain extent the decisions in relation to technology direction are about how to design, build, launch, market, support and maintain products and services, and to be effective in working within and directing communities of employees, users and partners in accomplishing large-scale outcomes (Hoving, 2007).

In turn, the transformation from central regulation to self-regulation will result in more people having greater freedom in the decision-making process. The researcher would say that the Jidoka concept could underpin the early stages of this transition, as the workers understand and are given the freedom to take appropriate action when needed without being instructed by management. This transformation requires actions to become more flexible in order to be self-managed. Thus, if the transition from closed to open intellectual properties takes place, ideas and information can be easily shared and accessed. This influences the direction of technology in relation to decision-making amongst leadership to deal with PESTLE factors, ensuring the direction of future technology and decision-making will be more transparent to both the public and stakeholders, making it easier for them to understand and provide feedback.

Accordingly, the driving force of open source may influence the leadership, where the key objective is to provide the best to society, from a closed source of profit motive to a non-profit motive. Consequently, leadership needs to deal with the decision of whether to patent (copyright) or waive (copyleft) technology to a certain degree. Technology could also be shared with the public or standardised, as a new way of patenting it to the public. In addition, leadership also needs to consider the greater need for innovation and non-technical innovation. Therefore, managing innovation and non-technical innovation are likely to be key issues in the future (Jong & Hartog, 2007; Ramaswamy, 2009).

Furthermore, netocracy, in the context of leadership, may ideally provide less red tape, so the direction of technology can be clear, as everyone could participate and the voices of everyone could be heard. This scenario may suit a knowledge-driven society. Yet the direction of technology is not just limited to the specific scope within an organisational context, but also extends outside of the organisation, to consider such matters as the complexity of the environment and unclear organisational boundaries. For instance, it could be predicted that leadership in areas of technology (i.e. networks) may tend to consider community opinion, such as peer recognition in gaining the approval of society more broadly. Similarly, leaders need to consider the demand for greater corporate social responsibility and environmental concerns when making decisions about the direction of their technology. In addition, selective/curious customers may also play a big part in this principle. For example, consider a rock band who have become popular and famous on YouTube, and have subsequently received a recording contract as a direct result of a high demand from fans. Thus, the increasing pace of change may happen in this way, as many people in the network provide ideas and feedback in a short space of time. Leaders can also make an immediate change when it is required. The pace of change in the direction of technology can be quicker as the result of this.

Flow of thought of Principle 4: Technology Partnerships / Supplier Participation

The principle of partnerships/supplier participation in the future could be based on:

- Suppliers and partnerships having a much closer relationship because of social integration and tightly integrated online supply chains.
- Relationships built upon trust, openness and transparency.

The relationship is becoming much closer as a result of social integration, with trust, openness and transparency at the core (Berger, 2007; Jahansoozi, 2006; M´alovics, et al., 2007). Having said that, suppliers and partnerships are likely to have a much closer relationship because of social integration and tightly integrated online supply chains (Chen, 2008; Karandikar & Nidamarthi, 2006; LaRoche, 2009).

This may happen as Web 2.0 provides the platform that allows suppliers to communicate, review and evaluate their partnerships. As a result, relationships are built upon trust, openness and transparency (openness in information). Therefore, communication becomes much clearer and misinterpretation is avoided, as mass information is made available for both parties to retrieve and access. Ideas and actions can come from the partnership immediately. For example, product specification, customer specification, reviews, comments and supplier partnership meetings can be uploaded onto the web. Indeed, supplier relationships tend to be built on the basis of trust, which brings greater flexibility in terms of decision-making and executing tasks.

Inevitably, in terms of moral regulation, such partnerships are not bound by rules and regulations; rather, the situation seems to be shifting to a symbiotic relationship. In such a scenario, people are willing to do good things without being instructed, with a greater emphasis on collective altruism (e.g. knowledge sharing among suppliers and partnerships). This leads to increasing transparency with a spirit of openness and sharing information.

As a consequence, new developments in technology are shared, and become the public standard (copyleft). This provides more opportunities for other parties, including suppliers, to create and enhance existing technology (from the open source concept). This leads to greater innovation. Innovation can happen in a faster manner throughout the network. In other words, suppliers become more innovative and create an environment where communication, the exchange of ideas and solutions takes place amongst suppliers and partnerships as a result of open source innovation, which, in turn, leads to more rapid decision-making and the avoidance of misinterpretation. The partners thereafter work closely with a greater emphasis on sharing knowledge in order to build greater collective intelligence amongst themselves (Karandikar & Nidamarthi, 2006; LaRoche, 2009; Mason & Rennie, 2007).

Moreover, the concept of netocracy involves eliminating unnecessary bureaucracy in making decisions and establishing corrective action in relation to supplier relationships; whereas the increasing emphasis on community opinion could help build a good profile and positive image of the business within the community. Further, all of these strengthen the view that there will be more third parties -

individuals and organisations - participating and collaborating in each other's business models.

In turn, the increasing emphasis on continuous learning in partnership/supplier relations makes it possible for them to learn from and update each other. In addition, the increasing pace of change also makes it possible for partnerships and supplier relationships to become more responsive.

Flow of thought of Principle 5: Technology Pioneering

In the future, pioneering technology will not only be about being at the forefront - or acting as the front-runner in technological development - but will include a greater emphasis on establishing a more collaborative network of technology, with architectures of participation built on collective intelligence (Grunert, et al., 2008; Ramaswamy, 2009).

In Web 2.0, the affect of this movement is based on the premise that it drives the pace of collaborative technology in the networks. In other words, the network inspires people in the organisation to perform and excel by reaching a higher potential and becoming technology pioneers. This includes putting a greater emphasis on building capacity and enhancing the knowledge base in order to become the pioneers of technology. In line with this thinking, self-regulation transforms people to be more open minded and take part in the cyber world/virtual communities of practice. This leads to greater pioneering technology via network collaboration, where the breakthrough of new technology in the market results from a strategic collaboration in networks.

The transition from a relational contract to relational trust results in unconditional trust, building confidence and sustaining competitive advantage within manufacturer/supplier/customer relationships due to transparency and collaboration. Also, the open source and copyleft movement makes it possible for companies to be sustainable and at the forefront of technology. Moreover, some companies may waive certain rights for reasons of improvement, in order to keep them competitive. As such, the increasing emphasis on innovation, including the greater usage of Web

2.0 and the open source movement, may stimulate innovation and spark new pioneering technology. To a certain extent, the transformation of netocracy (networks structure) could impact on the pioneering of technology, as this leads to a change from clear organisation to fuzzy organisation boundaries. Ideally, this movement eliminates rigid structures, loosens the decision-making process in relation to works and practices, and gives people within the organization the freedom to act. For example, in the case of Mozilla, Wikipedia and eBay, despite having limited workforces and flat structures, they remain technology pioneers.

This advances the view that, in the future, pioneering technology will not be about being the sole champion of R&D, or the technological leader in the market, which takes a great deal of time and is very costly. What will be of greater importance is the ability to produce breakthrough technology for the market, quickly and reliably, by working closely with partners that have superior competencies in certain areas (Chowdhry, 2010; Hoving, 2007).

As such, there will be increased productivity and efficiency as a direct result of quick responses through collaborative network technology, with architectures of participation built on collective intelligence. In addition, such a shift requires the organisation to deal with multiple resources and a richness of information, where the key concern is to disseminate and interpret such resources and information in order to obtain optimum results.

Also, the increasing emphasis on continuous learning would provide staff support for organisations in order to keep up-to-date (i.e. learning from blogs and social networking sites). Such learning could take the form of continuous learning amongst individuals in networks, and the end results could possibly enrich and strengthen the organisation in the long-term. In addition, technology pioneering may need to consider corporate social responsibility and the environment in order to be at the forefront of technology. Further, the shift from loyal customers to picky/curious customers reflects how customers could play a role in shaping leading technology in relation to producing the products or services. This suggests that the best technology does not always mean the best choice for the customers. As such, the increasing pace of change, and the quick response and accessibility as the result of networks, makes it possible for companies to pioneer technology.

In line with the above points, it is also predicted that pioneering technology through the use of 'cloud technology', the internet server (Corney, et al., 2010; Hildebrand, 2010; Iansiti, 2009). There is likely to be more big name players involved in cloud technology, since it enables firms to offer connectivity to their products to a larger customer base (shared resources and information). For example, the Sony Corporation use Google Inc. Android platform – the cloud, to release their on line Blu-ray television in the internet in order to reach more customers across the world (Anonymous, 2010c). Further, the shifts will bring more companies, especially in the music, movies and gaming industries, into cloud technology, with other industries following.

Flow of thought of Principle 6: Technological Integration

The future principle of technological integration within organisations would be based on technology becoming the driving force in leading innovation and integrating business as a new mode for communicating, collaborating, socialising and working together (Hamel, 2007; Nousala, et al., 2008; Shin, 2008). In addition, technological integration would also be based on the integration of internal and external systems with business models (i.e. a networking model) through 'inter-enterprise applications', made possible by the advancement of Web Services and ERP (Hoving, 2007). For example, ERP has made cross-functional systems a necessity with the corresponding need to integrate common processes and technologies across the departments and, to a certain extent, across company borders as well.

The wave of 2.0 movements advances the view that Web 2.0 takes the principle of integration to the next level. Integration happens in the form of Intranet 2.0, which makes it possible to provide comments, reviews, and discussions about problems and solutions across the organisation. Moreover, trust may play a large part in integrating business, strategy and technology, which leads to the promotion of unconditional trust. In turn, this suggests that, the more transparency there is, the higher degree of integration there could be. Thus, open source and copyleft movement may possibly act as the medium that gels together and integrates business, strategy and technology (i.e. open source innovation).

As a consequence, this leads to an increased emphasis on innovation that would inspire a greater development of new technology and integration within the organisation. Further, the increasing emphasis on continuous learning may result in interactive integration from one department to another within the organisation. In principle, technological integration is linked to business, and the refinement of strategy is concerned with corporate social and environmental responsibility, which also needs to be emphasised as a major business strategy. It is believed that the increasing pace of change may speed up and provide a platform for individuals to respond, in order to make it possible for greater integration within the organisation.

Accordingly, authors such as (Prahalad & Krishnan, 2008, p. 126), suggest that technological integration is about developing the capacity to rapidly integrate new technologies and legacy assets via networks – Information Communication Telecommunication (ICT) platform and as the systems that can be integrated for independent enterprise (Wei, et al., 2009). Hence, this may lead to globally integrated and locally responsive systems (Prahalad & Krishnan, 2008, p. 125).

Further, this shift results in the ability to use technology to integrate companies and ensure that all parties can properly react to supply chain disruptions, and implement a strategy to overcome problems and expand improvements. Leveraging integrated technologies, data is collected faster, allowing for a proactive analysis of the data to ensure more efficient and streamlined operations (Rabren, 2010).

Flow of thought of Principle 7: Technological Value

In the future, technological value would be delivered on the basis of technology as an ICT platform that provides engagement with customers. There will be more value placed on network collaboration for innovation, as well as providing access to free resources to allow more opportunities.

It is becoming clear that technology is likely to act as a platform that creates opportunities, to be expanded to host networking type functionality and collaboration tools (Gordon, 2010; Gosain, 2007). This happens in the transition from Web 1.0 to Web 2.0, which provides the value for technology in terms of speed (fast action and quick response), and access to people across the networks with interesting ideas and knowledge. Indeed, this creates wider coverage and unique improvement and development of technological value. Aside from that, it could be said that moral-based practices will provide greater value for technology, as new developments in technology will not only be based on legal matters, but also moral aspects. This reflects the view that the issue is not solely concerned with advancing good technology, but technology that is also morally right. In turn, the movement of increasing transparency and open source may create more opportunities and synergies for technology to be optimised in the networks. Thus, the copyleft movement may also create more value for technology as copyleft allows more innovative ideas to be implemented for replacing and improving existing technology in the market.

Accordingly, technology value requires greater emphasis on innovation, which can be seen throughout the network, as this, potentially, gives further added value to existing technology. Technological values, in the context of community opinion, means that communities of practice value the technology and give feedback, and this may involve an element of recognition and reputation. Occasionally, selective customers will reflect social changes, which may impact and shape the direction of technology in terms of providing value.

Thus, in principle, the realisation of technological value, not only through technology-to-market linking (where the technology is embodied in a product to be meaningfully employed and can create benefits for its users (Gruber, et al., 2008), but also by providing the capacity to engage customers in a wide variety of activities, such as product development, pricing and logistics (Prahalad & Krishnan, 2008). As such, the co-creation nature of this engagement can enable firms to learn about customers as part of a technological value creation process (Prahalad & Krishnan, 2008, p. 157).

Also, the shift provides the value for technology in terms of speed (fast action and quick response) and access to people across the networks with interesting ideas and knowledge. Indeed, this creates wider coverage and unique improvement, and the development of technological value as a whole.

Flow of thought of Principle 8: Technology Standards

The principle of technology standards (standards in technology) in the future could be based on open standards, where open technologies become the open networking standards. For instance, there will be more open linkages for business components (Gosain, 2007; Pramatari, 2007).

Specifically, the idea of Web 2.0 may drive the standard in technology to network standard. For instance, ideas and actions originating in the network, rather than internally, where, to a certain extent, the standard becomes public as a result of the open source movement. Thus, the standard could be self-managed, which makes it easy to track the guideline/network standard in networking (i.e. self-regulation). Further, increasing transparency makes it possible for a standard to be uploaded into a network where everyone can know and learn about it. The standard becomes open for the public to read, understand and even write some comments about it. It is fair to say that the shifting of the technology standard may also follow the network model (i.e. eBay) which puts greater emphasis on trust as a part of their success model.

In relation, ICT architecture allows the firm to continuously integrate new business processes and emerging technology standards with existing legacy systems and processes (Prahalad & Krishnan, 2008, p. 124). Business components have *open linkages* in which they connect with other components or external systems through standard and open interface, such as XML, and can be improved by Web services (Prahalad & Krishnan, 2008, p. 132).

As such, the researcher would say that open source movement, copyleft, and open source society, are the driving forces that could lead to a standard in networks. This means, to a certain degree, certain rights will be waived and remain open to the public. A situation is likely to arise in which intellectual property (i.e. industrial standard) becomes community property (public standard), as a new generation of users and consumers of intellectual property produced by new technologies bring totally different assumptions and attitudes to bear on its ownership. As brands become less the property of an organisation and more the banner of a movement, ownership will become even looser (Baldwin & Woodard, 2008; Eisenmann, et al., 2008; Iversen, et al., 2004; Song, Benedetto, & Parry, 2010). Also, this reflects a shift towards the netocracy movement, as the emphasis on network increases.

Inevitably, the increasing emphasis on innovation can be linked to transparency. The innovation on standards can happen in the form of innovative ideas, which provide better standards. In principle, the transformation of bureaucracy to a netocracy may encourage more people to provide better ideas for the improvement of existing standards. This includes the increasing emphasis on community opinion, where new standards come from the collective ideas from the communities of practice. This could happen with an increasing emphasis on continuous learning, and the idea that new products and services can be produced in better ways. Existing standards can be improved with continuous learning. Accordingly, from the standpoint of corporate social and environmental responsibility, every new standard (i.e. every potential network standard) needs to follow and commit to corporate social and environmental guidelines.

Overall, it is predicted that, in the future, open technologies will become the open networking standards. For example, Linux and Apache provide the most popular examples of open technologies, and their underlying communities, where members donate time, knowledge and collaborative effort to develop technology that is placed in the public domain (Waguespack & Fleming, 2009). To a certain extent, this means a shift to the development of open technical standards, where an individual is free to propose new technical standards. For example, Internet Engineering Task Force (IETF) community develop the internet standards (Waguespack & Fleming, 2009).

Appendix C: Mozilla Key Event

Table 1 below shows the chronology of Mozilla's development from the beginning of 1998 to present.

Table 1: Important Events in the Development of Mozilla

23 Feb 1998	Open for business
26 Feb 1998	Added the Search page
2 March 1998	Announced the new ``license'' newsgroup and mailing list in the Community section
5 March 1998	The draft license has been released
21 March 1998	Second draft license released
27 March 1998	Added a C++ Portability Guide
6 Apr 1998	Announced the initial release of Bugzilla, mozilla.org's bug-tracking system
9 Apr 1998	Added Windows Tools to the download page
12 May 1998	Bonsai is the Concurrent Versions System (CVS) query tool that gives an up - to- the - minute overview of what changes have been made to the source code
16 Jun 1998	The source code to the Bonsai and Tinderbox tools has been released
17 Jul 1998	A description of the Performance project has been added
24 Aug 1998	The source for PerLDAP (a set of Perl modules for managing Lightweight Directory Access Protocol (LDAP directories) is now available
26 Aug 1998	Bugzilla has been completely rewritten and the source is available, which distributed under the Mozilla Public License (MPL)
1 Sep 1998	Documentation for the ColorSync Project has been released. Sponsored in part by Apple Computer. Mozilla launched MozillaZine. MozillaZine provides the Mozilla community with up-to-the-minute news and informative and entertaining discussion forums on the web
17 Sep 1998	HTTP Compression Stage 1 has been completed. The combined netlib enhancement and Apache server module improve perceived performance by about 30% for an average session on a 28.8 modem
26 Oct 1998	The Mozilla development roadmap is available
15 Jan 1999	Bugzilla now has a new, simpler URL: http://bugzilla.mozilla.org
4 March 1999	Bugzilla's products have been renamed. The Old "Mozilla" product has been renamed to be "MozillaClassic".
31 March 1999	Quality Assurance debuts its new site. Opportunities to contribute for people who might not be coders but want to test and submit bug reports
2 Apr 1999	Mozilla's first birthday
5 Apr 1999	A new status update is online with updates for XPCOM, RDF, M4, NGLayout, Mail/News, and XPToolkit
6 Apr 1999	The JavaScript test library has been published
13 Apr 1999	netscape.public.mozilla.embedding has been created for discussion of embedding Mozilla components such as nglayout, ender, javascript into applications
3 May 1999	TechNetCast has released an in-depth streaming video interview: Netscape Gecko – building an open source browser
7 May 1999	The netscape.public.mozilla.rt-messaging newsgroup has been created for the discussion of real-time messaging and chat in Mozilla
13 May 1999	Roger B. Sidje, David Fiddes, and P. S. Karthikeyan have created a project for adding MathML to Mozilla
27 May 1999	Bugzilla can now track dependencies between bugs. It can generate pictures showing the dependency graph

28 Jun 1999	A newsgroup/mailing-list pair for the discussion of Seamonkey (the v5.0 Browser) has been created
2 Aug 1999	The new Blackwood project provides a set of facilities to better integrate the Java platform with Mozilla including OJI, an XPCOM/Java bridge, a Java DOM API, a Java WebClient API and Pluglets
28 Aug 1999	PerLDAP version 1.4 released
18 Jan 2000	Open Source Crypto Announced. The Sun-Netscape Alliance has announced that it will contribute Open Source PKI Projects to Mozilla, including Netscape Security Services and Personal Security Manager
10 Feb 2000	Open Source PKI code released. The first partial release of Open Source PKI code
29 March 2000	Mozilla World Tour. M14 Language packages are available for Bulgarian, Bosnian, Danish, German, Spanish, French, Hebrew, Japanese, Norwegian, Portugese, Russian, Swedish, Thai and Chinese
31 May 2000	Version 2.10 has been released of Bugzilla, the open source bug tracking system
15 Sep 2000	Open Source Crypto Library Released. NSS 3.1 Beta 1 has been released, including a new implementation of the RSA algorithm. This release provides, for the first time, a complete open source implementation of the Netscape crypto libraries
19 Sep 2000	New Check-in Rules. To improve code quality, mozilla.org now requires all changes to be approved by a designated Mozilla code reviewer
6 Dec 2000	Mozilla 0.6 released. Mozilla 0.6 is a milestone release based on the same branch as Netscape 6
9 Jan 2001	Mozilla 0.7 released
15 Feb 2001	Mozilla 0.8 released
26 Mac 2001	Mozilla 0.8.1 released
27 Apr 2001	Bugzilla 2.12 released
7 May 2001	Mozilla 0.9 released. Features a new cache, image library, help viewer, and greatly improved SSL and MailNews performance
7 June 2001	Mozilla 0.9.1 released
13 June 2001	Netscape has released Netscape 6.1Preview Release 1, commercial browser based on Mozilla 0.9.1
29 June 2001	Mozilla 0.9.2 released
2 Aug 2001	Mozilla 0.9.3 released
13 Aug 2001	Mozilla 0.9.2.1 released. Consisting of the open source code from which Netscape 6.1 was built
30 Aug 2001	Bugzilla 2.14 released. Bugzilla is the open source web-based bug tracking system used by mozilla.org and many other projects
14 Sep 2001	Mozilla 0.9.4 unleashed
19 Sep 2001	Mozilla Relicensing. 298mozilla.org has begun its previously announced plan to relicense Mozilla to make it more General Public License (GPL) compatible. More than 6000 Netscape Public License (NPL) files are being relicenced under the Mozilla Public License (MPL)/ General Public License (GPL)/Lesser General Public License (LGPL) triple licence
12 Oct 2001	Mozilla 0.9.5 released
31 Oct 2001	Mozilla 0.9.4.1 Source released. Consisting of the open source code from which the recent Netscape 6.2 release was built
20 Nov 2001	Mozilla 0.9.6 released
20 Dec 2001	Mozilla On Video. The first of the Developer Day videos are now available online
21 Dec 2001	Mozilla 0.9.7 released
7 Jan 2002	Bugzilla 2.14.1 released
23 Jan 2002	Mozilla assigned Peter Bojanic of Oeone for Mozilla 1.0 project
4 Feb 2002	Mozilla 0.9.8 released

14 Feb 2002	Mozilla BugDays. Mozilla works to clean up the bug database by weeding out duplicate reports, adding test cases, confirming and resolving bugs.
11 March 2002	Mozilla 0.9.9 released
18 Apr 2002	Mozilla 1.0 Release Candidate 1 released
10 May 2002	Mozilla 1.0 Release Candidate 2 released
23 May 2002	Mozilla 1.0 Release Candidate 3 released
5 June 2002	Mozilla 1.0 released
11 June 2002	Mozilla 1.1 Alpha released
22 July 2002	Mozilla 1.1 Beta released
28 July 2002	Bugzilla 2.16 released
13 Aug 2002	Oeone has released the source for its new Home Based Desktop product, an operating environment for Linux, based on Mozilla technologies
26 Aug 2002	Mozilla 1.1 released
29 Aug 2002	Netscape 7.0 released which is based on Mozilla 1.0.1
10 Sep 2002	Mozilla 1.0.1 released
11 Sep 2002	Mozilla 1.2 Alpha released
1 Oct 2002	Bugzilla 2.16.1 released O'Reilly creating applications with Mozilla Genko embedders and components are encouraged to sign up to receive notifications when interfaces are frozen or under review
16 Oct 2002	Mozilla 1.2 Beta released
26 Nov 2002	Mozilla 1.2 released
2 Dec 2002	Mozilla 1.2.1 released
13 Dec 2002	Mozilla 1.3 Alpha released
7 Jan 2003	Mozilla 1.0.2 released
10 Feb 2003	Mozilla 1.3 Beta released
13 Feb 2003	DevEdge Standards Redesign using advanced CSS and XML that demonstrates Mozilla's extensive W3C standards support and cross browser web development
6 March 2003	Camino 0.7 released
13 March 2003	Mozilla 1.3 released
1 Apr 2003	Mozilla 1.4 Alpha released
25 Apr 2003	mozilla.org's Mozilla Branding Strategy document explains long-term product naming strategy
7 May 2003	Mozilla 1.3.1 available Mozilla 1.4 Beta released
29 May 2003	Mozilla 1.4 Release Candidate 1 released
17 June 2003	Mozilla 1.4 Release Candidate 2 released
24 June 2003	Mozilla 1.4 Release Candidate 3 released
30 June 2003	Mozilla 1.4 released
22 July 2003	Mozilla 1.5 Alpha released
27 Aug 2003	Mozilla 1.5 Beta released
1 Sep 2003	MozillaZine turns five
4 Sep 2003	Thunderbird 0.2 released
17 Sep 2003	Mozilla 1.5 Release Candidate 1 released
26 Sep 2003	Mozilla 1.5 Release Candidate 2 released
10 Oct 2003	Mozilla 1.4.1 released
15 Oct 2003	Mozilla 1.5 released
31 Oct 2003	Mozilla 1.6 Alpha released
6 Nov 2003	ISC and universities provide hosting services
26 Nov 2003	Mozilla 1.5.1 update for Mac OS X
5 Dec 2003	Thunderbird 0.4 released
9 Dec 2003	Mozilla 1.6 Beta released
15 Jan 2004	Mozilla 1.6 released

9 Feb 2004	Thunderbird 0.5 released Mozilla released Firefox 0.8 web browser
23 Feb 2004	Mozilla 1.7 Alpha released
18 March 2004	Mozilla 1.7 Beta released
21 Apr 2004	Mozilla 1.7 Release Candidate 1 released
3 May 2004	MozillaZine Forums Hit Half A Million Posts. Only about one and a half years old, have reached 40,000 members and more than half a million posts Mozilla Thunderbird version 0.6 released
17 May 2004	Camino 0.8 Beta released Mozilla 1.7 Release Candidate 2 released Mozilla 1.8 Alpha 1
8 June 2004	Mozilla 1.7 Release Candidate 3 released
14 June 2004	Firefox 0.9 released
16 June 2004	Thunderbird 0.7 released
17 June 2004	Mozilla 1.7 released
23 June 2004	Camino 0.8 released
29 June 2004	Firefox 0.9.1 released Thunderbird 0.7.1 released
14 July 2004	Mozilla 1.8 Alpha 2 released
15 July 2004	Mozilla Foundation 1st Anniversary
2 Aug 2004	The Mozilla Foundation announces the Security Bug Bounty Program to encourage the identification and reporting of security issues. Program harnesses power of the open source community to identify vulnerabilities before they are exploited, as this program is designed to encourage security research in Mozilla software and reward those who help Mozilla create the safest Internet clients in existence
3 Aug 2004	Mozilla Firefox: Best in Show. Mozilla Firefox today received both the Best In Show and the Best Open Source Solution awards at Linuxworld Expo
18 Aug 2004	Mozilla 1.8 Alpha 3 released Mozilla Japan Created. The Mozilla Foundation and Mozilla Japan announced the launch of Mozilla-Japan.org web site and the creation of Mozilla Japan, that a non profit organisation that promotes, develops and help deploys Mozilla products in Japan
31 Aug 2004	New Web Site Launches - Mozilla.org
14 Sep 2004	Mozilla Foundation announced first payments of security Bug Bounty program. The first payments awarded to Marcel Boesh, Gael Delalleau, Georgi Guniski and Mats Palmgren, the first researchers and security experts to find and report qualifying vulnerabilities Firefox preview and Thunderbird 0.8 released
20 Sep 2004	1 Million Downloads in 100 Hours. The Firefox Preview Release was downloaded over 1 million times in the first 4 days after release
28 Sep 2004	Mozilla Suite 1.8 Alpha 4 released
17 Oct 2004	Firefox Preview Release: 5 Million Downloads. Firefox Preview Release passed the 5 million downloads milestone in just over 30 days, scattering all previous records
27 Oct 2004	The first release candidate build of Firefox 1.0 (RC 1.0)
3 Nov 2004	Thunderbird 0.9 released
9 Nov 2004	Mozilla released Firefox 1.0 web browser
22 Nov 2004	Update to German Language Version of Firefox 1.0. Over 24 localized versions of Firefox 1.0 available including: Asturian, Catalan, Czech, Danish, German, Greek, English, Spanish (Latin America), Finish, French, Hebrew, Hungarian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Romanian, Russian, Slovenian, Swedish, and Chinese (Traditional). Several more languages including Albanian, Chinese (Simplified), Dutch, Irish (Gaelic), Spanish (Spain),

	Turkish. Mozilla Firefox 1.0 builds momentum with record 5.6 million downloads in first two weeks. Mozilla 1.8 Alpha 5 released
7 Dec 2004	Thunderbird 1.0 released
13 Dec 2004	10 Million Downloads. Firefox 1.0 breaks the ten million downloads mark in first month, shattering all previous records
17 Dec 2004	Mozilla 1.7.5 released. One Million Downloads of Thunderbird 1.0. Mozilla's Thunderbird 1.0 email application has been downloaded over 1,000,000 times in the first ten days after release
10 Jan 2005	Thunderbird 1.0 passed 2 million downloads in the first month
12 Jan 2005	Mozilla 1.8 Alpha 6 released
15 Jan 2005	Bugzilla 2.18 released
16 Feb 2005	25 Million Downloads of Firefox. Mozilla Firefox has been downloaded 25 million times since it was made available on November 9, 2004. There are now more than 70,000 volunteers signed up at Spread Firefox
4 March 2005	Mozilla China Launched. Mozilla Foundation announced the launch of www.mozilla.org.cn and the creation of Mozilla China, a non-profit organization to help develop, promote, and deploy Mozilla products in China. The launch of Mozilla China follows similar international affiliate programs Mozilla Europe and Mozilla Japan
21 March 2005	Thunderbird 1.0.2 and Mozilla 1.7.6 released
29 Apr 2005	Firefox Surpasses 50 Million Downloads. Mozilla Firefox has been downloaded 50 million times since it was made available on November 9, 2004
14 June 2005	PC World's Product of the Year - Mozilla Firefox. Mozilla Firefox 1.0 web browser took the top spot on PC World's ranking of 100 best products for 2005. PC World named Firefox its "Best Product of 2005"
11 July 2005	Firefox on c|NET's Top 10 Download List. C|Net has ranked the Mozilla Firefox Web browser as the Number Four download on its list of all-time Top 10 downloads since c|Net's inception in 1995
19 July 2005	Firefox 1.0.6 released and Thunderbird 1.0.6 released
26 July 2005	Firefox Exceeds 75 Million Downloads. Mozilla Firefox has been downloaded 75 million times since it was made available on November 9, 2004
3 Aug 2005	Mozilla Foundation Reorganizes. Mozilla Foundation today announced it has formed a wholly owned subsidiary to be known as the Mozilla Corporation. The Mozilla Corporation is a taxable subsidiary that serves the non-profit, public benefit goals of its parent, the Mozilla Foundation, and the vast Mozilla community. It will continue to leverage resources from diverse sources to create and distribute great open and free-of-charge end-user products that promote choice and innovation on the Web
10 Aug 2005	Mozilla Store 2.0 Launched. The Mozilla Foundation announced the grand reopening of its online store, the Mozilla Store, which sell Mozilla CDs, books and promotional merchandise
8 Sep 2005	Firefox 1.5 Beta 1 released
9 Sep 2005	Thunderbird 1.5 Beta 1 released
20 Sep 2005	Firefox 1.0.7 Released
29 Sep 2005	Thunderbird 1.0.7 released. This update is available for Windows, Mac OS X and Linux
6 Oct 2005	Firefox 1.5 Beta 2 released
7 Oct 2005	Thunderbird 1.5 Beta 2 released
19 Oct 2005	Firefox Surpasses 100 Million Downloads. Firefox adoption numbers have exceeded expectations with more than 100 million downloads since Firefox's introduction in 2004

1 Nov 2005	Firefox 1.5 Release Candidate 1 released
3 Nov 2005	Mozilla Corporation kicks off ‘Extend Firefox’ competition to encourage development of extensions to the award-winning Firefox Web browser
4 Nov 2005	Thunderbird 1.5 Release Candidate 1 released
9 Nov 2005	Mozilla Firefox 1st Birthday
10 Nov 2005	Thunderbird 1.5 Release Candidate 2 released
17 Nov 2005	Firefox 1.5 Release Candidate 3 released
29 Nov 2005	Mozilla introduces Firefox 1.5
12 Jan 2006	Mozilla releases Thunderbird 1.5 email client
2 March 2006	Mozilla announces winners of "Extend Firefox" Competition. Contest generates over 200 new extensions for the award-winning browser
12 Apr 2006	Mozilla showcases first round of community produced “Firefox Flicks” videos. Mozilla today began showcasing the first round of community-created videos promoting Firefox
18 Apr 2006	Mozilla receives over 280 Community Produced Videos for “Firefox Flicks”
21 Apr 2006	Mozilla released Thunderbird 1.0.8 and 1.5.0.2 email client
1 June 2006	Mozilla released Thunderbird 1.5.0.4 email client
27 July 2006	Mozilla released Thunderbird 1.5.0.5 email client
31 Aug 2006	Firefox 2 Beta 2 milestone released
14 Sep 2006	Firefox 1.5.0.7 security and stability update released Mozilla released Thunderbird 1.5.0.7 email client
26 Sep 2006	Firefox 2 Release Candidate 1
11 Oct 2006	QUALCOMM launches project in collaboration with Mozilla Foundation to develop open source version of Eudora Email program
24 Oct 2006	Mozilla released major update to Firefox 2.0
7 Nov 2006	Adobe and Mozilla Foundation to open source flash player scripting engine Mozilla released Thunderbird 1.5.0.8 email client
4 Dec 2006	The world economic forum announced 47 Technology Pioneers for 2007. Mozilla has been selected as one of these technology pioneers
11 Dec 2006	Mozilla Firefox headed for primetime. Firefox fans create and sponsor videos on TV
19 Dec 2006	Mozilla released Thunderbird 1.5.0.9 email client
7 Feb 2007	Kodak and Mozilla join forces to make sharing photos even easier
1 March 2007	Mozilla released Thunderbird 1.5.0.10 email client
27 March 2007	Mozilla launches new Firefox add-ons web site. Mozilla launched a new Firefox add-ons web site that makes it even easier for Firefox users to find and install thousands of free extensions and themes for a totally customized browsing experience
28 March 2007	Mozilla and eBay working together to make the auction experience easier for Firefox users in France, Germany and the UK. Mozilla and eBay are collaborating on new technology and approaches to enable eBay users to stay up to date with their auctions more easily from within Firefox regardless of where they are on the Web
19 Apr 2007	Mozilla Thunderbird 2 email client released
16 May 2007	United Nations Agency awards Mozilla World Information Society Award. International Telecommunication Union selects Mozilla for its outstanding contribution to the development of world-class internet technologies and applications
30 May 2007	Mozilla released Thunderbird 1.5.0.12 email client
14 June 2007	Mozilla released Thunderbird 2.0.0.4 email client
4 July 2007	Mozilla and eBay launch Firefox companion for eBay users. Free Firefox add-on makes eBay trading easier, faster and safer
19 July 2007	Mozilla released Thunderbird 2.0.0.5 email client

1 Aug 2007	Mozilla released Thunderbird 2.0.0.6 email client
23 Aug 2007	Mozilla released Thunderbird 1.5.0.13 email client
17 Sep 2007	David Asher joins Mozilla to lead new organisation
14 Nov 2007	Mozilla released Thunderbird 2.0.0.9 email client
19 Dec 2007	Mozilla released Thunderbird 1.5.0.14 email client
7 Jan 2008	Mozilla appoints John Lilly as Chief Executive Officer. Mozilla Corporation announced the appointment of chief operating officer John Lilly as its CEO, effective immediately
19 Feb 2008	Kick off development of Thunderbird 3
26 Feb 2008	Mozilla released Thunderbird 2.0.0.12 email client
1 May 2008	Mozilla released Thunderbird 2.0.0.14 email client
17 June 2008	Mozilla released Firefox 3 and redefined the web experience. Major performance enhancements and revolutionary 'Awesome Bar' makes Firefox 3 the fastest, smartest, most powerful browser Mozilla has ever released
2 July 2008	Mozilla Sets New Guinness World Record with Firefox 3 Downloads. Mozilla announced it set a new Guinness World Record for the largest number of software downloads in 24 hours. The record-setting 8,002,530 downloads coincided with the launch of Firefox® 3, Mozilla's major update to its popular and acclaimed free, open source Web browser
23 July 2008	Mozilla released Thunderbird 2.0.0.16 email client
29 Aug 2008	Google and Mozilla extended their search partnership until 2011
25 Sep 2008	Mozilla released Thunderbird 2.0.0.17 email client
12 Nov 2008	Mozilla released Firefox 3.0.4
18 Nov 2008	Mozilla released 'Fashion Your Firefox', a new web application that enables Firefox users to customise their browser based on their interests and online activities
19 Nov 2008	Mozilla released Thunderbird 2.0.0.18 email client
3 Dec 2008	Mozilla And Zazzle announce strategic relationship for apparel on-demand. Mozilla dedicated to promoting choice and innovation on the Internet, and Zazzle, the leading on-demand retail platform for consumers and major brands, today announced a strategic relationship for apparel on-demand. Through the relationship, Zazzle will host a special Mozilla community store featuring an array of community-generated designs on a variety of apparel for purchase, with full customisation
8 Dec 2008	Mozilla Firefox 3.1 Beta 2 released
30 Dec 2008	Mozilla released Thunderbird 2.0.0.19 email client
4 Feb 2009	Mozilla Firefox 3.0.6 released
21 Jan 2010	Mozilla Firefox version 3.6 released
31 March 2009	Mozilla adds style and star power to Firefox with new Personas through Mozilla Lab
30 June 2009	Mozilla advances the Web with the released of Firefox 3.5
16 July 2009	Mozilla released Firefox 3.5.1
20 Aug 2010	Mitchell Baker Honored as the Recipient of Frost & Sullivan's 2010 Growth, Innovation and Leadership Award. Mitchell will be honored for her achievements at the annual GIL 2010 event in Silicon Valley on September 13, 2010
24 Aug 2010	Mozilla released Firefox 4 Beta Updated with Sync – syncing data across devices and Panorama
27 Aug 2010	Fennec Alpha released for Android and Nokia N900. The Alpha release of the next major version of Fennec is now available for Android and Nokia N900 users to download and test
7 Sep 2010	Mozilla released Firefox 4 Beta with faster graphics and new audio capabilities for the web

14 Sep 2010	Mozilla released a new JavaScript benchmark named Kraken. Kraken focuses on realistic workloads and forward-looking applications
20 Sep 2010	Firefox Home released. Firefox Home, a free app that syncs Firefox browsing history, bookmarks and open tabs to iPhone or iPod touch, is now available in 15 languages worldwide
21 Sep 2010	Mozilla joined Open Invention Network as a licensee. OIN is an organisation which helps protect the Linux ecosystem by building a variety of defences against patent attacks
7 Oct 2010	Firefox 4 beta for mobile is available to download and test. It is built on the same technology platform as Firefox for the desktop and optimized for browsing on a mobile phone
14 Oct 2010	Mozilla appointed Gary Kovacs as new CEO. His first day will be November 8^{th}