INTEGRATING TOC AND TRIZ FOR SERVICE PROCESS IMPROVEMENT

CHENG YONG

NATIONAL UNIVERSITY OF SINGAPORE

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CHENG YONG

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Summary

Theory of Constraints (TOC) and Theory of Inventive Problem Solving (TRIZ) are two methodologies that originate from manufacturing context and technical field. Their application is largely limited to technical fields, although they have been proven powerful in non-technical areas. This thesis is an exploratory study on the effective use of TOC and TRIZ in a non-technical area. Specifically, a framework which integrates TOC Thinking Process (TP) and TRIZ is proposed to aid practitioners involved in service process improvement in systematic problem identification and innovative problem solving.

The proposed framework combines the strength of TOC TP in systematic problem identification with least investment and the strength of TRIZ in creative and innovative idea generation based on its powerful knowledge base. Compared to other service process improvement methodologies, the proposed framework does not require significant investment and involvement of entire workforce. This feature makes it especially appropriate for Small and Medium Enterprises (SMEs) who often lack necessary resources to implement service process improvement initiatives.

Compared the traditional way of integrating these two methodologies, a modified approach is adopted in the framework to enable the use of various TRIZ tools for idea generation. Moreover, as many TRIZ tools have obvious technical features which hinder its application in services, this study also provide the service version of TRIZ tools including 39 generic parameters and Su-Field Analysis. Practitioners can utilize the framework more easily with the aid of the service version of TRIZ tools.

To test the proposed framework, five real-life case studies illustrating the usage of TOC TP and TRIZ tools for service process improvement are presented in this thesis as a form of empirical verification. Finally, the contributions and limitations of this framework are presented. Some recommendations for future research in the area of TOC and TRIZ for services are also discussed.

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Nomenclature

5FS	5 Focusing Steps
AD	Axiomatic Design
ARIZ	Algorithm of Inventive Problem Solving
BS	Brainstorming
CIT	Critical Incident Method
CLR	Categories of Legitimate Reservation
CPS	Creative Problem Solving
CRT	Current Reality Tree
DBR	Drum-Buffer-Rope
DEPC	Dynamic Event Process Chain
DFSS	Design for Six Sigma
DOE	Design of Experiment
EC	Evaporation Cloud
FRT	Future Reality Tree
IFR	Ideal Final Result
NBR	Negative Branch Reservation
NLP	Neuro-Linguistic Programming
NM	Nakayama Masakazu
PRT	Prerequisite Tree
QFD	Quality Function Deployment
SADT	Structure Analysis and Design Technique
SME	Small and Medium Enterprise
SPN	Severity Priority Number
STA	Service Transaction Analysis
TA	Throughput Accounting

TOC	Theory of Constraints
TP	Thinking Process
TQM	Total Quality Management
TRIZ	Theory of Inventive Problem Solving
TT	Transition Tree
UDE	Undesirable Effect
VE	Value engineering
WTA	Walk Through Audit

Chapter 1 Introduction

The dominating role of service sectors in developed economies is now widely recognized. OECD statistical data for 2003 attributes approximately 70% of the GDP to services in numerous developed countries (Machuca et al. 2007). According to Lee (2008), statistics from Singapore showed that 76.7% or about 1.377 million of residents aged 15 years and over were employed in the service industry in 2006 and the service industry contributed about 63.5% to GDP in 2005. Meanwhile, the process nature of services is emphasized by most scholars, and service process quality attributes an important part to the overall service quality. There two points highlight the importance of a well-managed service process to customers and service organizations. Therefore, effective and systematic service process improvement is necessary for service organizations to achieve service excellence and customer satisfaction. This thesis aims to integrate TOC TP and TRIZ for systematically and innovatively improving various service processes.

In this chapter, the thesis background and objective of this thesis are presented. Meanwhile, a complete description of the thesis structure is explained at the end of this chapter.

1.1 Thesis Background

This section discusses the increasing importance of dedicated tools for services companies. Meanwhile, the importance of small and medium enterprises (SMEs) to national economy is also discussed. As such, the resulting motivations of this thesis are

presented.

1.1.1 Tools Transfer for Services

In spite of the significant growth of the service economy, there is an evident mismatch between the importance of services and the insufficient research in academia. To accelerate the research progress in services, IBM initiated Service Science, Management and Engineering (SSME) program as a new academic discipline and research area, but wide knowledge and skill gaps still exist in this new discipline. Filling these gaps requires not only new theories and techniques invented in services but also some valuable ones from the manufacturing industry. Actually, many theories and techniques originating from the manufacturing industry have been proven effective for services. For example, Six Sigma, introduced by Motorola in 1986, has been utilized by many world-class manufacturing companies such as General Electric, Motorola, Honeywell, ABB, etc. It has also been embraced by many big service companies such as JP Morgan, American Express, City Bank, etc. For another example, Just-in-time (JIT), a formalized process of waste reduction in the manufacturing industry, has also been applied to service operations. Canel et al. (2000) pointed out the areas of the greatest potential for improving performance of service organizations through JIT implementation. They also presented examples of JIT applications in the service industry.

Nowadays, to achieve competitive advantages and enhance business performance, manufacturing companies are increasingly developing service dimensions of their businesses as a way of adding value to their core product offerings. Vandermerwe and Rada (1988) defined this phenomenon as “servitization”, which blurs the distinction

between manufacturing activities and traditional service activities. Baines et al. (2009) noted that several other researches, product-service systems (PSS) as an example, are closely related to servitization, with the only differences in the motivations and geographical origins of research communities. Their study showed that servitization practitioners currently lack engineering tools or techniques which help them to handle the service dimensions of their businesses. Therefore, it is very beneficial for them to utilize some of their familiar manufacturing-oriented tools or techniques which can also be transferred to the service industry as well.

1.1.2 Tool Requirements for SMEs

According to the business statistics from Singapore Department of Statistics (SingStat) in 2007, SMEs accounted for 99% of total enterprises in Singapore and contributed almost half of total enterprises' value-added (SingStat 2007).

To survive and prosper, all businesses including large organizations and SMEs need to continuously improve all facets of their operations. However, compared to large organizations which enjoy economies of scale, SMEs suffer from lack of financial resources, scant opportunities to recruit specialized workers, insufficient external information on which to base decisions, and lack of management time (Ghobadian and Gallear 1996; Vrande et al. 2009). Thus, SMEs tend to be less innovative because of those limitations or barriers. For example, SMEs usually cannot afford the significant initial investment in process improvement programs such as Six Sigma. The associated costs and extensive technical trainings required by Six Sigma prevent owners from improving their processes, even though they may be aware of the necessity. Therefore, one tool requirement for SMEs is that the tool should help SMEs to focus on their most

critical problems in their processes, and it does not require much capital investment, time, and many human resources.

Ghobadian and Gallear (1996) argued that SMEs have weak ties with their environment, and SMEs are usually skeptical of inter-firm interaction and information sharing. On the contrary, Jong and Marsili (2006) found that SMEs appear to be fairly open, as more than half of sample companies have explicit search strategy for new knowledge and participate in formal inter-firm collaborations. Whatever the viewpoints they had, both of these two studies stressed that it is important for SMEs to utilize external knowledge and information to enhance their innovation capability. Therefore, the second tool requirement for SMEs is that the tool should provide SMEs with a knowledge base which can support SMEs in innovation.

Compared to large companies, SMEs are usually managed by their owners, and managers or owners in SMEs are responsible for many decisions, and thus many planning process is not formal and takes place within individual minds (Ghobadian and Gallear 1996). Therefore, for the process improvement, the tool should provide SMEs with a systematic way and procedure. Developing a process improvement methodology which meets the tool requirements of SMEs is meaningful for them to achieve competencies.

Two methodologies, TOC and TRIZ, which have been proven powerful in the manufacturing environment, are capable of being applied in any situation for systematic improvement and inventive problem solving. This study believes that those two methodologies could make positive contribution to service firms or manufacturing

firms which are currently making a transition to servitized organizations. Meanwhile, This study also believes that these two methodologies can meet the special tool requirements of SMEs in the service industry.

1.2 Objectives

The main goal of this thesis is to develop a formalized framework which helps service firms to improve their service processes in an innovative way and with the least investment. This thesis first reviews the extant literature on service process, TOC, and TRIZ. Then we develop the framework and list the details of how to implement this framework. Finally, case studies are used to support and verify the effectiveness of proposed framework.

1.3 Thesis Structure

This thesis consists of 7 chapters which include an introduction to the thesis, literature review of service process, introduction of TOC and its application in services, TRIZ concepts and its application in services, the framework building, research methodology, results and implications, and final discussion and conclusion. The thesis structure is shown in Figure 1-1.

Chapter 1 introduces the service economy and the background of this thesis, the objectives of this research is then established. Finally, a brief description of the thesis structure is presented.

Chapter 2 reviews some key concepts related to the service process, including process nature of service, process improvement methodologies, and introduction to some typical process-oriented tools with their own merits and limitations.

Chapter 3 is a review of TOC, covering the introduction to its three basic branches - logistics/production, performance measurement, and thinking process. Then, the current state of TOC application in the service industry is described based on the literature retrieval and analysis.

Chapter 4 reviews the basic concepts of TRIZ, integration of TRIZ with various tools, especially with TOC TP, for different purposes. Finally, the current application of TRIZ in services is summarized and presented.

The framework of integrating these two methodologies for service process improvement is built in chapter 5. This chapter also presents detailed step-by-step instructions including analyzing the process and related problems, constructing the current reality tree, identifying the directions for improvement, and generating solutions to contradictions or mini-problems.

Chapter 6 discusses the research methodology which was adopted by this research. The research design including methodologies and sampling is firstly introduced. This thesis conducted two-phase research. The phase 1 research used web survey, and the phase 2 research used case studies. In this chapter, the data collection methods and analysis methods for these two phases are presented.

Chapter 7 presents the results for each phase. The phase 1 produces a list of common problems in the restaurant service process. Then, the phase 2 presents five case studies to empirically test the framework proposed in the chapter 5. Finally, the implications for those results are discussed.

Finally, Chapter 8 concludes the whole thesis by summarizing the contributions of this thesis project. Then, limitations of the research are discussed. Finally, some recommendations for the future research are presented.

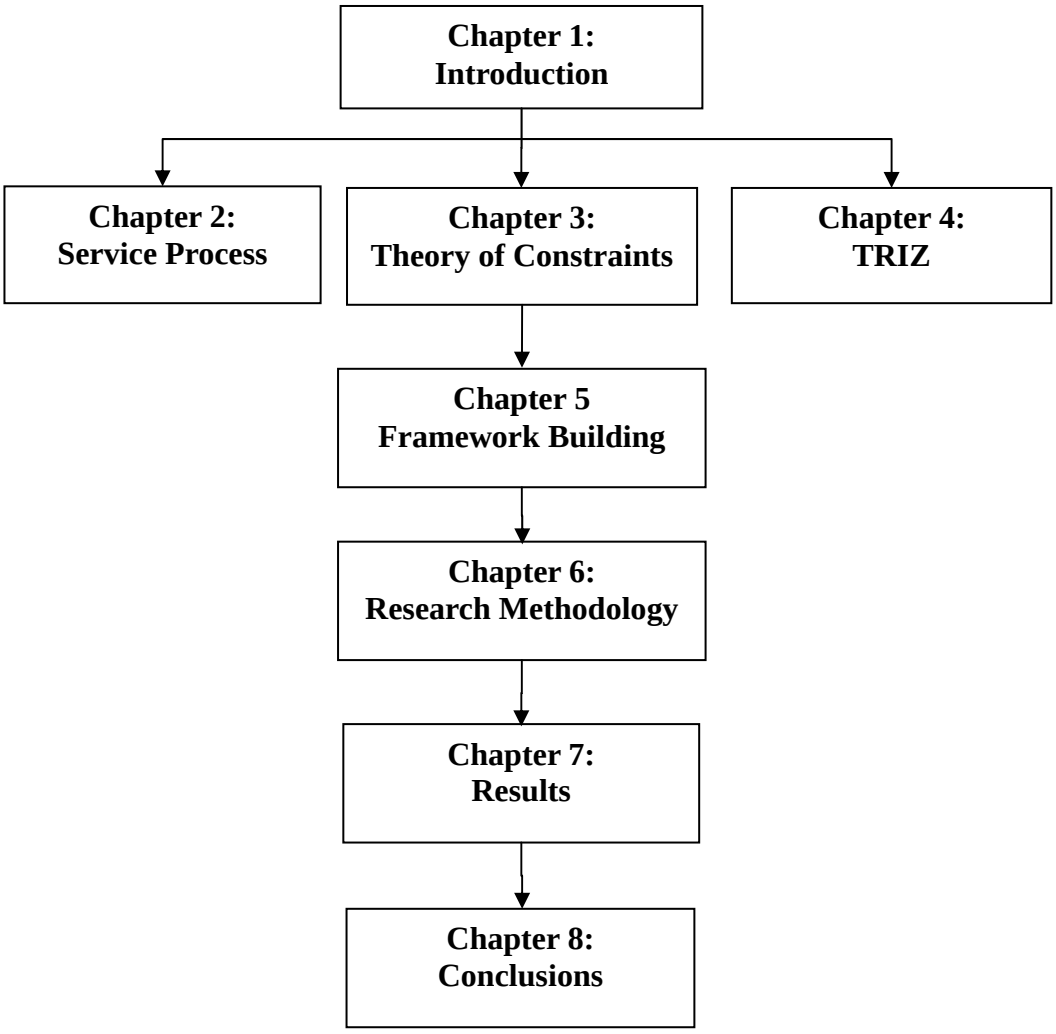


Figure 1-1: Thesis Structure

Chapter 2 Service Process

One of the most important characteristics of service is its process nature. The review on service process covers the process nature of services, service quality and importance of process quality, various process improvement methodologies, and tools for service process design and improvement.

2.1 Services as Processes

Scholars from different disciplines try to define what the service is. Different viewpoints result in inconsistent or even contradictory definitions on the nature of service (Alter 2008). A well-known service definition described service by analyzing the unique service characteristics, namely IHIP (Intangibility, Heterogeneity, Inseparability, and Perishability) that differentiate service from the physical product. However, this definition has been receiving different degree of criticism regarding its ability to capture the essence of service. One of its weaknesses is that it is unable to capture the process nature of service. Compared to the tangible goods, services are dynamic, functioning over a period of time through a sequence or a series of interrelated events and steps, thus many scholars have pinpointed the process nature of service (see Table 2-1). “Performances, processes, and deeds”, the three most frequently used keywords in their definitions, explicitly symbolize the process nature of service. Edvardsson et al. (2005) indicated that some other words in various service definitions including activities (Grönroos 2000) and experiences (Fitzsimmons and Fitzsimmons 2006; Johnston and Clark 2001) also reflect the process nature of service. In this thesis, we use the concise definition from Zeithaml and Bitner (2003).

Table 2-1: Service Definitions

Author(s)	Definition
Sasser et al. (1978)	A service is intangible and perishable. It is an ***occurrence*** or ***process*** that is created and used simultaneously or nearly simultaneously.
Lovelock (1991)	A ***process*** or ***performance*** rather than a thing.
Tinnilä and Vepsäläinen (1995)	Service as a concept refers to a wide variety of ***processes*** and ***exchanges***.
Grönroos (2000)	An ***activity*** or series of ***activities*** of a more or less intangible nature that normally, but not necessarily, take place in the interaction between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems.
Zeithaml and Bitner (2003)	Services are ***deeds***, ***processes***, and ***performances***
Vargo and Lusch (2004)	The application of specialized competences (skills and knowledge), through ***deeds***, ***processes***, and ***performances*** for the benefit of another entity or the entity itself (self-service).

Service process can be defined as the chain or chains of parallel and sequential activities which must function if the service is to be produced (Edvardsson and Olsson 1996). A service process consists of a part of partners' activities and a part of customers' activities and all activities related to the service within a company. In this course, a number of different types of resources including human resources, customers, technologies, and organization environment, i.e. the component of service system in Edvardsson and Olsson's model, are utilized and glued by the service process.

2.2 Service Quality and Importance of Service Process

2.2.1 Service Quality Dimensions

Service quality is known to be conceptualized and measured across multiple dimensions. From different viewpoints, researchers proposed various service quality models with different dimensions. As a reference, Seth et al. (2005) reviewed 19 conceptual service quality models covering domains from personalized services to internet-enabled services.

Grönroos (1984) proposed the "perceived service quality model" which suggests that the service quality is perceived and evaluated by consumers, and the actual service received by consumers is not directly used to determine the service quality. Generally, service quality can be divided into two components, i.e. process/functional quality and result/technical quality (Grönroos 1984; Harvey 1998; Kang and James 2004). The result quality refers to what a customer receives as the outcome of a service provided. The process quality is how the customer obtains those results by engaging themselves in a service process. Grönroos (1984) also introduced the "corporate image" as the third dimension of service quality. However, its role is almost treated as a filter in perception of the other two dimensions, and most researchers exclude the image from their service quality dimensions.

Process quality is measured by using five main variables designed in SERVQUAL (Parasuraman et al. 1985; 1988). SERVQUAL is a survey instrument that has extensively been used in marketing as well as operations management. It mainly focuses on the service delivery process. These five variables include tangibles, reliability, responsiveness, assurance, and empathy.

On the other hand, Kang and James (2004) indicated that no latent determinants associated with the result quality have been found. It may be attributed to the fact that service results usually vary significantly across different service sectors. Furthermore, some service results, especially those produced by the leisure and entertainment sectors, are highly subjective. The customers often lack the ability to articulate what the result quality is. The service quality dimensions can be illustrated in Figure 2-1 (Please note that the R, A, T, E, R, and R, from top to down, represent the service items or elements concerning reliability, assurance, tangible, empathy, responsiveness, and result quality, respectively).

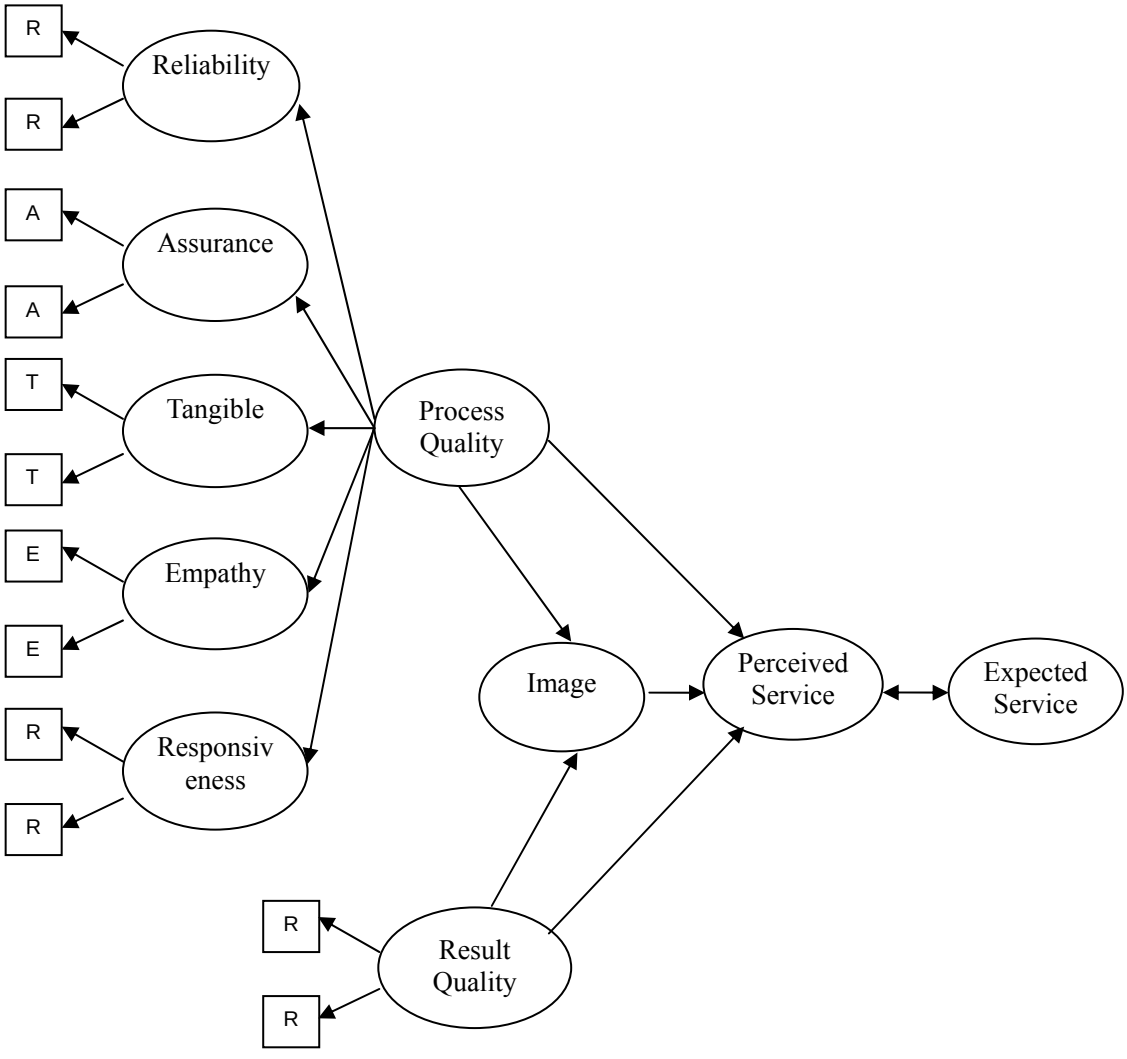


Figure 2-1: Service Quality Dimensions

(Adapted from Grönroos 1984, and Kang and James 2004)

2.2.2 Importance of Process Quality

Despite the fact that service quality requires both the process quality and the result quality, these two components do not have the same weight in the overall service quality. In many cases, process quality is more important than result quality, and the reasons are provided as follows.

(1) According to Harvey (1998), result quality is the order-qualifying criterion, meaning that it qualifies a service company in the market. Improving or exceeding the result quality is proven to be very difficult. On the contrary, process quality is often the order-winning criterion, which is the key to maximize the competitive advantage for a service company.

(2) As discussed above, some service results are highly subjective, resulting in the customer's inability of assessing the result quality. In these cases, customers can only rely on the measures of process quality to evaluate the delivered services.

2.3 Process Improvement Methodologies

To improve service quality and gain customer satisfaction, many industries have moved to a process and system way of thinking. Instead of focusing on individual events, the entire process and system need to be analyzed for an effective process improvement. For the systematic process improvement, TOC is often compared with other methodologies: Six Sigma and Lean (Nave 2005; Reid and Cormier 2003). In addition, Discrete-event simulation (DES) has been used to study and optimize a vast array of complex system (Connelly and Bair 2004). Therefore, Six Sigma, Lean, and

DES are selected and discussed as follows.

Lean is an effective business improvement methodology that is commonly used in manufacturing. Lean focuses on the flow of processes, and strives to minimize various forms of waste that is not necessary to produce the product or service. From the proposed concept of lean service by Womack and Jones (1996), many researchers and practitioners have advocated lean adoption in services (Abdi et al. 2006; Atkinson 2004; Bowen and Youndahl 1998; Corbett 2007). In service organizations, lean is implemented as a methodology to reduce time waste and to allow the process to become more efficient (Delgado et al. 2010). For service process improvement, Maleyeff (2006) conducted a meta-analysis of 60 internal service systems, and found numerous similar structure characteristics and common problems between the process-system of manufacturing and service businesses. However, successful implementation of lean requires "an incredible amount of detailed planning, discipline, hard work, and painstaking attention to detail", therefore only midsized and large companies are likely to implement lean (Evans and Lindsay 2008). Most SMEs are constrained by inadequate funding and leadership deficiencies, so they fear that the lean implementation is costly and time consuming (Achanga et al. 2005).

Six Sigma is a data-driven and team-centered approach that focuses on reducing process variation by the use of quantitative, advanced statistical methods. Six Sigma uses a powerful method, DMAIC (Define, Measure, Analyze, Improve, Control), to resolve quality problems. Since it was introduced by Motorola in the 1980s, Six Sigma has been widely implemented in many manufacturing companies. However, there are very limited application of Six Sigma in service sectors except the health care and

financial services (Chakrabarty and Tan 2007). As service processes are largely people-driven, measurements are often non-existent or ill-defined (Evans and Lindsay 2008), and data collection is one of the most serious problems faced by the service organizations which intend to implement Six Sigma (Chakrabarty and Tan 2009). In addition, although large organizations have been implementing Six Sigma and reaping the benefits from it, its application in SMEs is still very limited due to lack of financial resources, human resources, time, and knowledge (Kumar and Antony 2009). Small organizations are often confused and intimidated by the size, costs, and extensive technical training required by Six Sigma implementation (Evans and Lindsay 2008).

DES has been widely applied to the modeling of operation systems in the manufacturing industry. Since 1990s, simulation has been increasingly used in the service sectors such as airport (Gatesleben and Weji 1999), business process (Melão and Pidd 2003), and health care (Connelly and Bair 2004; Jun et al. 1999). Simulation approach helps to gain a bird's-eye view of the entire system and identify the process bottlenecks by accurately documenting the real system into a simulation model. However, simulation modeling and analysis can be time consuming and expensive. Most simulation models are quite large and involve large programming project if the magnitude of the problem is considerable. Meanwhile, extensive time may be required for data collection, analysis, and interpretation for initializing model parameters. As the DES usually needs numeric data to initialize the model, it is ineffective when a service process cannot be quantitatively described.

In summary, the reviewed process methodologies including Lean, Six Sigma, and DES have their own strengths in improving service process in a systematic way. However,

they often require numeric data for decision making, thus limiting their implementation in the service process improvement when the problems cannot be quantitatively described. Meanwhile, these methodologies often require many resources for technical training, financial supporting, and project implementation. These resource requirements heavily constrain the spread of these methodologies through SMEs.

2.4 Process-Oriented Tools

With regard to the individual tools, researchers and practitioners has been developing many process-oriented tools to engineer the service process improvement. This study reviews the typical process-oriented tools currently applied in the service industry. These tools are identified by the literature review of books related to service quality, service operations, and service process (e.g. Evans and Lindsay 2008; Fitzsimmons and Fitzsimmons 2006; Johnston and Clark 2001). To learn more details of these tools and identify possible additional tools, the author then retrieved the journal articles regarding these tools from databases including ABI/Inform (ProQuest), Elsevier Science Direct, IngentaConnect, EBSCO, Emerald Insight. These identified tools from the books and journal papers are discussed as follows.

2.4.1 Walk-through Audit (WTA) and Service Transaction Analysis (STA)

WTA is a customer-focused survey based on a checklist of questions which guide the surrogate customers to assess their experience in a service delivery process (Fitzsimmons and Fitzsimmons 2006; Johnston and Clark 2001). The surrogate customers may be employees, managers or independent advisers who are often

required to undertake the complete audit in person, thus the total customer experience from the customer's perspective and the perception gaps between customers and managers can be correctly evaluated. Further suggestions on improvement or redesign of the service process are derived through the data analysis. WTA has been used in many areas to examine the service quality or customer experience in a service process (e.g. Fitzsimmons and Maurer 1991; Koljonen and Reid 2000; Rowley 1999).

STA reinforces the WTA through combining the service concept, service process, transaction quality assessment, and service messages, so it provides a more structured way to assess and improve the customer experience in a service process (Johnston 1999; Johnston and Clark 2001). Actually, STA technique integrates the elements of WTA and sequential incident analysis (Hume et al. 2006). STA tries to identify the perception mismatches between expected services and actual services by explicitly specifying the service concept, walking through the actual process, and recording the customer assessment of each transaction encounter and reasons or messages for the assessment. Improvement ideas for the service process are developed by analyzing these mismatches and the identified reasons (Johnston 1999).

Both the Walk-though audits and STA techniques do not merely investigate individual complaints or initiatives, but force the managers and employees to view the process from the customer's perspective. In addition, STA also explicitly identifies the reasons for the results or outcomes of each service transaction. However, they only investigate the sub-process involving the customers, i.e. the customer process. Other sub-processes in the front-office or back-office are not addressed or investigated.

2.4.2 Structure Analysis and Design Technique (SADT)

SADT, also known as IDEF, is invented by Douglas T. Ross as a graphic tool to describe human-directed activities in complex systems. The SADT modeling process produces a set of interrelated diagrams that collectively describe a system (Congram and Epelman 1995). SADT has been successfully applied in various industries since its commercialization in 1973. In services, SADT has been frequently used for modeling the back-office operations such as cheque-processing operations (Lindquist 1992) and hospital processes (Jackson 1992). Congram and Epelman (1995) summarized several points that make SADT especially effective for services:

(1) SADT focuses on activities which are building blocks of services.

(2) SADT exclusively provides controls (what guide or constrain the activity) and mechanism (who or what performs the activity). They are important attributes for structurally describing a service.

(3) SADT is valuable in improving the internal communication between employees, managers, and customers.

Congram and Epelman (1995) demonstrated the usefulness of applying SADT to improve a tax return process. They argued that SADT offers service managers and service providers a methodology for reaching organizational consensus about service processes, and it provides opportunities for effective internal communication and collaborative learning about service process excellence.

However, SADT also suffers from several limitations. For example, SADT is a static modeling tool that represents the structure with data flow instead of the dynamic behavior of the service process over time, thus it is difficult to use SADT for service

process change and improvement.

2.4.3 Dynamic-Event Process Chain (DEPC)

DEPC, developed by Kim and Kim (2001), is based on the Event-Process Chain modeling method that supports the modeling and redesigning business process with a strong customer focus. DEPC is a diagram tool with five basic modeling constructs: event, process, branching, flow, and wait. These constructs are drawn on two dimensions: station dimension vertically and time dimension horizontally.

Through comparing DEPC with other process modeling methods including Service Blueprinting, flow chart, and SADT, Kim and Kim (2001) argued that only DEPC reflects all of the four representation perspectives (functional, behavioral, organizational and informational) in the service process modeling. In addition, its diagrammatic form eases the communication between customers, employees and managers. However, DEPC only deals with the customer-involved process, but it ignores other sub-processes which are also important for service quality and customer satisfaction.

2.4.4 Fail-Safing

Fail-safing, also named as mistake-proofing or Poka-Yoka, was developed and refined during the 1960s by Shigeo Shingo, a Japanese manufacturing engineer, who created and formalized Zero Quality Control.

Fail-Safing is one of the most useful concepts to prevent human errors from being defects in the end product (Chase and Stewart 1994). Though it is originally production

or product oriented, it is applicable in services. According to Chase and Stewart (1994), fail-safing a service process requires identifying where and when failures generally occur. Once a failure is identified, the source must be found. The final step is to prevent the mistake from occurring through source inspection, self-inspection, or sequential checks. Fail-safing can effectively help identify service errors (task, treatment, and tangible) and customer errors (preparation, service encounter, and resolution). However, fail-safing treats those errors independently and lacks a systematic way to improve the problematic process.

2.4.5 Service Blueprinting

Service Blueprinting, initially invented by Shostack (1982; 1984), is defined as a map or flowchart that visualizes all transactions constituting the service process. After three important stages of development with new elements added (Fließ and Kleinaltenkamp 2004), Service Blueprinting becomes a flexible and powerful tool which has hitherto been applied to a wide spectrum of service processes at multiple levels of analysis.

Service Blueprinting depicts a service process by adopting the horizontal and vertical dimensions. Service Blueprinting possesses several merits over other tools. Firstly, Service Blueprinting is relatively simple and its graphical representation provides all the involved stakeholders with a common point of discussion for new service development and improvement. It allows different people to understand and deal with it objectively regardless of their roles or their individual viewpoints (Bitner et al. 2008; Zeithaml and Bitner 2003).

Secondly, Service Blueprinting provides designers and managers with an opportunity

to identify potential points of failure. Service Blueprinting can be combined with the failure analysis techniques like fail-safing (Chase and Stewart 1994) and FMEA (Chuang 2007) to reduce the likelihood of various failures in a service process at the design stage.

Thirdly, according to Bitner et al. (2008), Service Blueprinting, compared to other process-oriented techniques and tools, is the first and foremost customer-focused technique that can capture the entire customer service experience from the customer's point of view.

Although Service Blueprinting is demonstrated as a useful tool in the service process design and improvement during the last two decades, it still has several inherent limitations. Firstly, all the possible failures identified by Service Blueprinting are often symptoms of hidden problems. Solving these symptoms is often unable to eliminate the root causes for achieving fundamental improvement. In addition, Service Blueprinting does not determine the degree of severity for identified failures, thus resulting in the difficulty of decision making.

In addition, although Service Blueprinting encourages creativity and preemptive problem solving (Shostack 1984), it is essentially more powerful in process modeling rather than problem identifying and solving. The process of seeking recommended action mainly depends on prior knowledge and brainstorming technique, which are recognized as inefficient ways to search the innovative solutions.

2.4.6 Conclusion

The review on the various process-oriented tools shows that each of these tools has their inherent limitations. Most of them only address parts of a service process rather than the whole one. Without a system view, clear understanding of service processes may be hampered (Narasimhan and Jayaram 1998). Although Service Blueprinting can encompass all different activities in a service process, it is essentially a process modeling tool. It may help to reveal many potential problems, but it cannot determine which one is the most critical. Meanwhile, it also lacks ability to find the innovative solutions, i.e. it is weak in problem identification and problem solving. Tools which are specialized in problem identification and problem solving should be introduced to the service field to enhance the process improvement, thus bringing competitive advantages to service companies.

Chapter 3 Theory of Constraints

3.1 Introduction to TOC

Theory of Constraints, originally developed by Eliyahu M. Goldratt in 1984, has gradually evolved from the simple optimized production techniques into a management philosophy which helps organizations continually achieve their goals. From the perspective of TOC, any process within an organization can resemble a steel chain, of which the weakest link determines the overall strength. The capacity of the weakest link, called constraint in TOC terms, always exists in an organization and limits the organization from achieving higher performance in terms of its goal. According to TOC, improvement efforts in an organization should focus the limited time and resources on the performance of constraints, so as to achieve global performance improvement across the whole organization.

For the process improvement, TOC is often compared with other methodologies: Six Sigma and Lean (Nave 2005; Reid and Cormier 2003). In short, Six Sigma is a data-driven and team-centered approach that focuses on reducing process variation by formal data collection and analysis. Lean thinking or Lean Manufacturing focuses on the flow of processes, and strives to minimize various forms of waste that is not necessary to produce the product or service. TOC is a logic-driven approach that focuses on system improvement by better management of the single activity or process that constrains the system performance. According to Reid and Cormier (2003), TOC provides a leverage point for the whole system improvement. Unlike Six Sigma and Lean, TOC does not require extensive data analysis and involvement of the entire work force (Nave 2005). In summary, TOC helps to achieve the most improvement for the

least investment. Generally, TOC studies can be classified into three interrelated areas: logistics/production, performance measurement, and thinking process (Spencer 2000).

3.1.1 Logistics/Production

The logistics/production area is also known as the ongoing improvement which is based on the five focusing steps (5FS): (1) identify the system's constraint; (2) decide how to exploit the system's constraint; (3) subordinate the rest of the system to the constraint before acquiring new capacity; (4) elevate the system's constraint; and (5) return to step1 if a constraint is broken. Besides 5FS at the highest level, TOC has also developed a number of heuristics and techniques including logical product structure and VAT analysis at the operations level, and buffer management and drum-buffer-rope (DBR) production scheduling method at the detailed level. Among these techniques, the most fundamental and common application of 5FS is DBR. It deals with the market constraints or physical constraints within the production process and changes the process operation style from push to pull.

3.1.2 Performance Measurement

The second area is performance measurement, which aims to focus an organization on the actions that can improve its overall financial performance. This measurement system, named Throughput Accounting (TA), begins with three critical financial measures – throughput (T), inventory (I) and operating expense (OE). In the TOC view, the goal of an organization is to make money now and future. Therefore, increasing the rate of throughput is the primary target, while reducing inventory and operating expense are respectively in the secondary place. It is also notable that the definitions

for these measures are different from those adopted by cost accounting which is older but still dominant management accounting. For example, throughput in TOC is the rate at which money is generated through sales or interests. Anything produced but not sold is not considered as throughput, so this definition by TOC encourages cross-functional coordination within an organization (Gupta and Boyd 2008). Based on these three basic financial measures, TOC has developed a suit of global performance measures, constraint measures, decision-support measures, and control measures.

These measures of TA allow managers to understand the contributions of constrained resources to the overall profitability of an organization, so the managers can accordingly make decisions to drive the organization toward its goal.

3.1.3 Thinking Process (TP)

The third area of TOC is known as the Thinking Process, which is applicable in any problem solving situation. The underlying working principle of TP is almost the same as that of 5FS, i.e. focusing on identifying and breaking the constraints for performance improvement. When a constraint is clearly identifiable, 5FS provides a simple but effective approach for continuous improvement. However, 99 percent of an organization's constraints are policies, which are often hidden in complex situations and difficult to be identified (Motwani et al. 1996). Fortunately, the TP provides a rigorous and systematic framework to innovatively resolve those complex ill-structured policy problems.

The framework originally consists of five logic diagrams: Current Reality Tree (CRT), Evaporating Cloud (EC), Future Reality Tree (FRT), Prerequisite Tree (PRT) and

Transition Tree (TT), and a set of logic rules, the Categories of Legitimate Reservation (CLR). This framework is implemented in the way of answering following three questions:

(1) What to change?

(2) What to change to?

(3) How to cause the change?

To answer the first question, CRT is utilized to identify the root causes of several observed symptoms as the evidence that the current system does not perform well to meet its goal. Usually, there are often many symptoms in a system or process. After establishing the improvement goal, a manager can obtain several obvious symptoms through direct observation of the current system and analysis of customer complaints. Then the manager starts to build CRT from these symptoms and possibly adds other symptoms which are not found in the first place. Among the identified root causes, the one which leads to the majority of symptoms is regarded as the core problem or system constraint, and it is the answer to the question of "What to change?". Once the core problem has been identified, EC is constructed to clarify the core conflicts and develop injections as the proposed solutions. These proposed solutions will be examined by FRT to reveal their future impacts on the organization and ensure that the negative branches will not result from the implementation of the proposed solutions. The validated solutions answer the question of "What to change to?". Finally, PRT and/or TT are built based on the solutions to determine how to overcome obstacles to the successful implementation of those solutions, as well as to develop the specific implementation plans for the solutions. These two logic tools guide the improvement team to answer the third question of "How to cause the change?".

Mabin and Balderstone (2003) and Spencer (2000) considered TP as the most important one among the three areas, because it challenges more fundamental assumptions and policy constraints. Meanwhile, it is capable of being applied in any situation. For examples, Gattiker and Boyd (1999) documented the ability of the TP tools to direct continuous improvement efforts to achieve significant improvement in terms availability and customer service in an electronic manufacturing plant. Rahman (2002) used TP tools to identify the critical success factors and relationships among these factors in SCM. Taylor et al. (2003) applied TP to various human resource problems during hiring process in a police department. Kim et al. (2008) reviewed 57 TP application papers, showing that TP has been applied in all aspects of business, such as supply chain management, marketing and sales, production, accounting, and services. They indicated that the advent of TP broadens the areas of TOC application beyond the manufacturing industry.

According to Watson et al. (2007), TP tools and those tools associated with lean, quality management, and process reengineering are mutually supportive, and the integration of tools from various sources may result in a better understanding of the problems and systems. Kim, et al. (2008) indentified that about one quarter of TP articles focused on integrating TP with established methodologies and tools including TRIZ, OR/MS methods, and system dynamics, and they regarded it as an important research domain in future.

3.2 Current State of TOC in the Service Industry

To date, TOC gradually transits from niche to mainstream, and it evolves into a

management philosophy. However, most TOC tools were originally developed and implemented in manufacturing, and thus TOC was considered by many to be tightly linked to the manufacturing (Reid 2007). Therefore, TOC receives relatively little attention from managers in the service sectors. Thus it has not been widely adopted by the service industry. This section aims to depict the current state of efforts for adapting and implementing TOC in the service industry.

3.2.1 Search Methodology and Results

The first step of the literature retrieval process is to search ABI/Inform (ProQuest) (up to and including 2008) database for journal articles and dissertations. The retrieved results revealed 274 contributions with the words “theory of constraints” in title, abstract, and keywords. Then we narrowed down the search results with “service” in title, abstract, and keywords. After this step, we found that only 29 papers were qualified. Each paper retrieved through this process was carefully reviewed before making a decision regarding its relevance. Finally, 20 papers (18 journal articles and 2 dissertations) in this database were identified as applying TOC in the service industry.

In the second step, we applied the same retrieval process to other well-known databases including Elsevier Science Direct, IngentaConnect, EBSCO, Emerald Insight, Informaworld, Scopus, JSTOR, Wiley InterScience, and Swetwise. The papers retrieved were compared with the results in the first step. After eliminating the repetitive items and reviewing the content, we found 5 new contributions including 3 journal papers and 2 conference papers. Therefore, we found 25 relevant scholar papers in total. This retrieval process demonstrated that the service application accounts for less than 10% of all TOC studies.

3.2.2 Result Analysis

With regard to the sectors of activity, it can be seen from Table 3-1 that the majority of TOC application in services (32%) is in the healthcare sector. Although the category of public services accounts for 12%, all the three papers were presented by the same authors and dealt with the same case, so it may be more appropriate to treat them as one contribution (the same situation occurs in the transportation category). In the second place lies the generic category. Studies in this category did not focus on any specific service sector. Two studies in professional services respectively dealt with issues from engineering surveying service and engineering consulting service. Finally, one contribution can be found for each of the rest service sectors, and no study has been found in many other important service sectors such as telecommunications, leisure and tourism, education, postal, etc. It can be seen that the quantity of TOC studies in the service industry is much smaller than that in the manufacturing industry. Meanwhile, application of TOC in services mainly focuses on the healthcare sector, and thus it is worthwhile to widen its application across other service sectors.

With regard to the research methods, the majority are empirical studies (88%) which consist of 18 case studies and 4 surveys for hypothesis testing, while only 3 papers are theoretical/conceptual studies. It is not surprising to have this result, since the theoretical basis of TOC has already been developed in manufacturing, and researchers only need to simply transfer those concepts to services with some adaptation. It is also very straightforward to find that all theoretical/conceptual studies and 3 out of 4 survey studies focused on generic services, while the case studies covered different service sectors.

Table 3-1: TOC Application in Different Service Sectors

Service sector	Quantity	%
Agriculture services	1	4
Banking	1	4
Healthcare	8	32
Professional services	2	8
Public services*	3(1)	12
Restaurant	1	4
Security services	1	4
Transportation*	2(1)	8
Generic	6	24

*All papers in this category can be treated as one contribution.

How TOC related tools were used in those studies is also interesting to explore. Since the theoretical/conceptual articles and the survey did not explicitly address this topic, we only investigated this subject by examining case studies. With regard to the tool usage in these case studies, 8 papers used 5FS and standard applications, and 11 papers adopted TP and related tools for change management and problem solving (one study utilized both 5FS and EC). Table 3-2 shows a tendency that TP and related tools have been receiving more attention in services since 2000. This may be attributed to the fact that services have some unique characteristics such as intangibility, inability to be inventoried, and simultaneous production and consumption. It seems that these characteristics impose more challenges to adopt conventional TOC 5FS and standard applications in services. Conversely, TOC TP is designed out of context restrictions, and it is equally applicable in manufacturing and service context to resolve the ill-structured problems and latent policy constraints. Based on this fact, TOC TP should be a better choice for solving service problems. However, the number of pertinent studies does not match its potential for service problems. The insufficiency

studies suggest the research opportunity of widening the application of TOC TP in various service sectors. On the other hand, TOC TP tools have been integrated with other tools from TRIZ, OR/MS, and system dynamics to be mutually supportive, but no previous study of such integration for services has been found. Kim, et al. (2008) also proposed these two same research opportunities in their literature review work.

Table 3-2: TOC Methods or Tools Used in Service Case Studies

Author(s)	5FS & Standard Applications				Thinking Process Tools					
	5FS	DBR	VAT	TA	CRT	EC	FRT	NBR	PRT	TT
(Chen et al. 2008) (Chen and Chou 2006)					**x**	**x**	**x**		**x**	**x**
(Gupta and Kline 2008)	**x**			**x**						
(Taylor and Thomas 2008)					**x**	**x**	**x**		**x**	
(Reid 2007)	**x**									
(Reid and Shoemaker 2006) (Shoemaker and Reid 2006)					**x**	**x**	**x**	**x**	**x**	**x**
(Walker and Cox 2006)					**x**					
(Umble and Umble 2006)		**x**								
(Ritson and Waterfield 2005)					**x**	**x**	**x**	**x**	**x**	**x**
(Shoemaker and Reid 2005)					**x**	**x**	**x**			
(Taylor and Churchwell 2004)					**x**	**x**	**x**			
(Reid and Cormier 2003)					**x**	**x**	**x**	**x**		
(Spencer 2000)	**x**	**x**		**x**		**x**				
(Roybal et al. 1999)	**x**									
(Olson 1998)			**x**							
(Jaideep et al. 1996)		**x**								
(Jaideep and Kathleen 1996)	**x**									

In conclusion, the search results suggest insufficient studies concerning application of TOC TP in services, whether in terms of the quantity or the scope. More theoretical studies along with case studies are needed to widen its application in service industry. In addition, how to unleash its maximum potential in services through integrating with other well-developed tools is also worth exploring.

Chapter 4 TRIZ

4.1 Introduction to TRIZ

TRIZ, a Russian acronym for Theory of Inventive Problem Solving, was developed by Genrich Altshuller (1926-1998) and his colleagues in former Soviet Union. It is defined as a human-oriented knowledge-based systematic methodology of inventive problem solving (Savransky 2000). TRIZ is now recognized as a very powerful methodology, and it is commonly associated with systematic innovation (Stratton and Mann 2003; Terninko et al. 1998), meaning that it can make the innovation process more predictable. Gao et al.(2005) compared the strengths and weaknesses between common innovation methodologies and TRIZ, and they pointed out that TRIZ is the most powerful one among them.

This section aims to review some basic concepts of TRIZ, current integration of TRIZ with other tools for various purposes, and the current state of applying TRIZ in the service industry.

4.1.1 Basic Logics of TRIZ

TRIZ research hypothesizes that there are universal principles of creativity. By identifying and codifying these principles, they could be taught to people to make the creativity process more predictable. After several stages of research during the last sixty years, TRIZ practitioners have reviewed more than three million patents worldwide, and identified three main findings (Domb 1998b):

(1) Problems and solutions repeat across industries and sciences;

(2) Patterns of technical evolution repeat across industries and sciences;

(3) Creative innovations use scientific effects outside the field where they were developed.

Intuitively, the methods of solving problems arising from different areas would be unique to each other. However, TRIZ recognizes that these repeated patterns of problem-solutions, evolutions, and scientific effects can be regarded as the general or universal instruments for solving the similar but specific problems across various engineering areas and non-technical areas. Figure 4-1 shows the TRIZ problem solving logic. The area in the dashed box represents the field in which TRIZ is powerful.

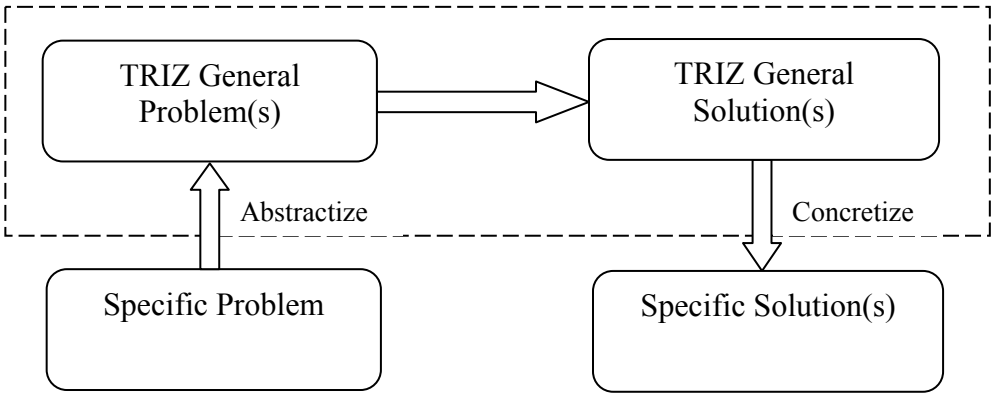


Figure 4-1: TRIZ Problem Solving Logic

4.1.2 Principles

Three basic principles upon which TRIZ is built make it distinct from other problem solving techniques:

(1) Systems evolve towards the increase of ideality: Ideality is defined as a qualitative expression: “Useful functions/(Cost + Harmful function)”. Systems always change towards the ideal state where all useful functions are realized

without any cost or harm incurred. All the other forms of evolution in TRIZ can be universally viewed as movements in the direction of increase of ideality.

(2) Systems are full of inherent contradictions: Contradictions occur when improving one parameters or characteristics of a system negatively affects the same or other parameters or characteristics of the system. According to TRIZ, the most effective inventive solution of a problem is acquired by solving the contradictions. TRIZ contains tools to solve various contradictions.

(3) Resources must be fully utilized: In TRIZ, a resource is broadly defined as everything that can be applied to solve problem and improve the system without any large expenses. Every system has resources that are not fully used, or even not identified. Easy introduction of new resources often complicates the system and leave the contradictions unsolved. TRIZ requires that contradictions are overcome only with no or minimal introduction of resources.

4.1.3 TRIZ Problem Solving Process and Associated Tools

Based on the basic principles, TRIZ has developed a set of tools as criteria, principles, or "rule of thumb" to help practitioners effectively utilize the TRIZ knowledge base for problem solving. Some most commonly used tools include: Contradiction Matrix, 40 Inventive Principles, 4 Separation Principles, Ideal Final Results (IFR), Su-Field Analysis, 76 Standard Solutions, Algorithm of Inventive Problem Solving (ARIZ), Resources, Evolution Patterns, Trimming, etc. These tools are not independent from each other, but they are correlated and there often exist overlaps between them. Users may find that several tools can be used to solve the same problem. Based on the basic problem solving logic shown in Figure 4-1, TRIZ researchers identified the structured TRIZ problem solving process in which each tool can be appropriately utilized at

different stages. Starting from an identified specific problem, TRIZ problem solving process goes through main stages of problem definition, problem resolution, and problem evaluation. The whole process and tools used at each stage are shown in Figure 4-2.

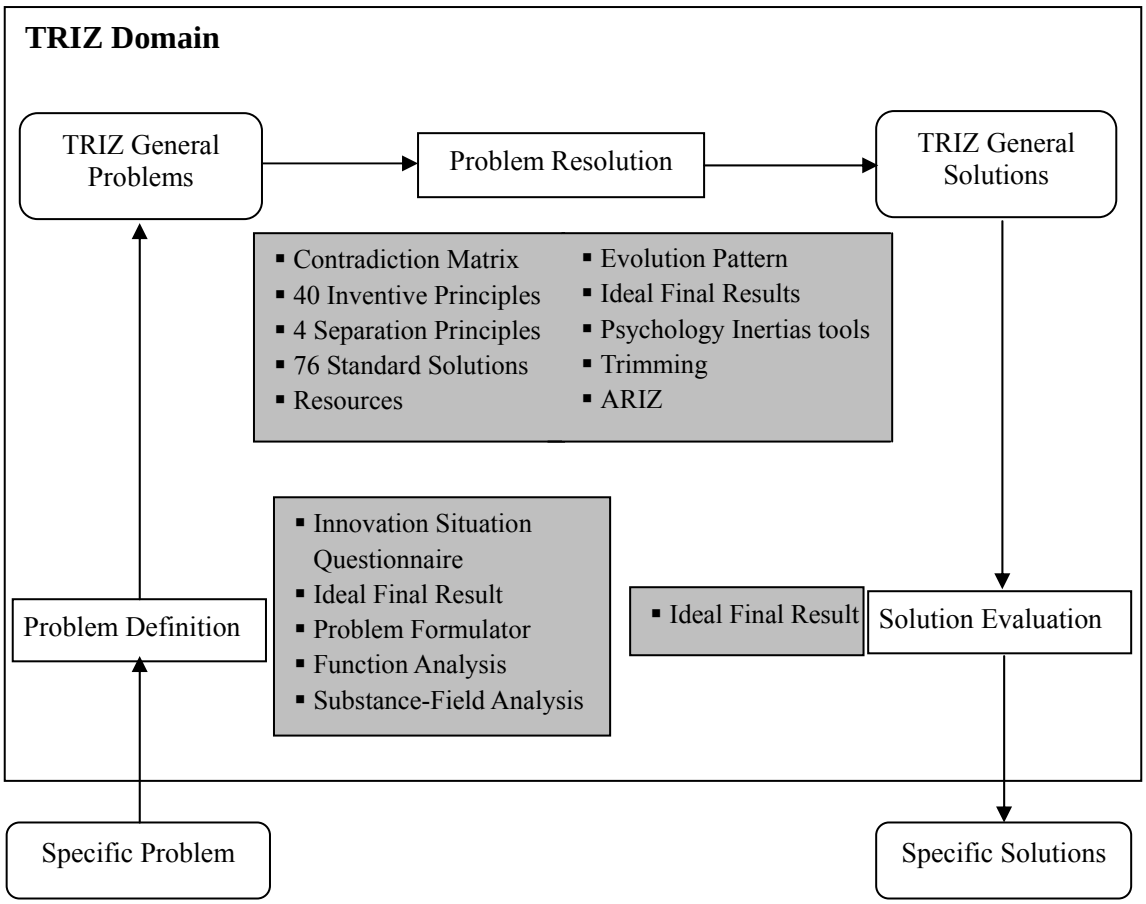


Figure 4-2: TRIZ Problem Solving Process and Associate Tools

4.1.4 Conclusion

TRIZ has been proven as a very powerful methodology to help problem solvers creatively and systematically generate ideas and solutions. The concepts of ideality, non-compromising solution, and a structured problem solving process make it distinct from other techniques. However, it also possesses some limitations. Firstly, TRIZ is

powerful when a specific problem has been identified or the problem is clearly identifiable, but it is relatively weak in problem identification when the original problem situation is complex. Figure 4-1 shows that TRIZ is not specialized in identifying the specific problems. Moura (1999) as an experienced TRIZ practitioner indicated that it is often hard for TRIZ users to ensure that the problem being solved is the right problem. Luke (2002) also pointed out that the number of possible problems will significantly increase when users use TRIZ problem modeling tools in a complex situation. This limitation is one important reason why TRIZ has been integrated with other tools. Secondly, although TRIZ has a great potential in non-technical fields, it has not been commonly used in these non-technical fields. One barrier is that TRIZ is too complicated for new learners to master due to its wide spectrum of heuristics and tools. Furthermore, these heuristics and tools are mostly invented in the technical field, thus most of them possess technical characteristics, and almost all the TRIZ introduction textbooks explain these heuristics and tools with examples from the technical perspective (see for examples, Altshuller 2000; Rantanen and Domb 2008; Savransky 2000; Terninko et al. 1998). Adapting or modifying TRIZ heuristics and tools for non-technical fields is necessary to accommodate non-technical problems (Toshio 2003).

4.2 Integration of TRIZ and Other Tools

4.2.1 Overview

As a powerful problem solving methodology, TRIZ has been gradually accepted by many practitioners in various fields including but not limited to product design and improvement. However, TRIZ is also proven more difficult for a beginner to command

than other problem solving skills like brainstorming. Furthermore, although TRIZ is powerful at problem solving and idea generation, it cannot replace other tools such as voice of customer, robust design, and etc, and it cannot cover all the issues in an organization. Therefore, TRIZ is usually integrated with the existing tools or methodologies when it is introduced into an organization.

The review of TRIZ related literature shows that the purposes of integrating TRIZ with other tools or methodologies are generally classified into three categories: (1) product design & improvement; (2) organizational improvement; (3) problem solving capability enhancement. Table 4-1 summarizes the topics covered in each category.

For product design and improvement, TRIZ often serves in the phase of concept design to generate innovative concepts, while other tools respectively focus on translating voice of customer (Quality Function Deployment, QFD), robust design and optimization (Taguchi; Design of Experiment, DOE), hierarchy analysis of multiple function system (Axiomatic Design, AD), function analysis (Reverse Fishbone Diagram, RFD), value enhancement (Value Engineering, VE), quality improvement (Design for Six Sigma, DFSS), and constraint identification (Theory of Constraints, TOC). In most cases, the integration is realized in a linear or loose way, i.e. each tool fulfills its own task without much overlap. Relatively, some authors proposed to use a tightly-coupled integration which requires two tools working together almost in each step. In any case, integrating TRIZ with those tools enables the mutual complement to each other, thus offering opportunities to find better solutions which cannot be accomplished by using a single tool.

Table 4-1: Integration of TRIZ with Other Tools or Methodologies

Product Design & Improvement	TRIZ+QFD	(Domb 1998a; León-Rovira and Aguayo 1998; Schlueter 2001; Terninko 1998; Ungvari 1999; Wang et al. 2005; Yamashina et al. 2002)
	TRIZ+Taguchi/DOE	(Apte and Mann 2001; Hsing 2001; Hu et al. 2000; Monplaisir et al. 1999; Wu 2004; Zhao 2003)
	TRIZ+AD	(Ahn and Lee 2006; Kankey and Ogot 2006; Lee and Ahn 2006; Mann 1999a; 1999b; Zhang et al. 2004)
	TRIZ+VE	(Chuksin et al. 2003; Sawaguchi 2000; 2001; 2002)
	TRIZ+RFD	(Cao et al. 2004; Tan et al. 2003)
	TRIZ+DFSS	(Reynard 2008; Ru et al. 2005)
	TRIZ+TOC TP	(Conradie et al. 2005; Domb and Dettmer 1999; Hua et al. 2006; Liu et al. 2008; Mann 2007b; 2007a; Mann and Stratton 2000; Moura 1999; Wei et al. 2008)
Organizational Improvement	TRIZ+Six Sigma	(Kermani 2003; Kumar 2005)
	TRIZ+TOC TP	(Mann and Stratton 2000; Pfeifer and Tillmann 2004; Stratton and Mann 2003; Stratton and Warburton 2003; 2006)
	TRIZ+TQM	(Domb 1997a; 1998b; Hashemi 2004; Skrupskis and Ungvari 2000)
	TRIZ+Lean	(Lakshminarayanan 2007; Saeger 2007; Slocum 2004)
	TRIZ+SWOT	(King 2004)
Problem Solving Capability Enhancement	TRIZ+BE	(Mansoorian and Naeini 2005; Mansoorian 2007)
	TRIZ+BS	(Campbell 2003; Nakamura 2001)
	TRIZ+CPS	(Hipple 2005)
	TRIZ+MindMaps	(Care and Mann 2001)
	TRIZ+NLP	(Becker and Domb 1998; Bridoux and Mann 2002)
	TRIZ+NM	(Nakamura 2003)
	TRIZ+Six Thinking Hats	(Mann 2001)

For organizational improvement, TRIZ is introduced to enhance the creativity and innovation capability and provide non-compromising solutions for continuous quality

improvement (Total Quality Management, TQM; Six Sigma), waste elimination and process flow improvement (Lean), and strategy planning and improvement (TOC; Strengths-Weaknesses-Opportunities-Threats analysis, SWOT). TRIZ has been integrated with these methodologies to different extents ranging from idea generation to framework rebuilding. For example, Domb (1998a) and Skrupskis and Ungvari (2000) have investigated the integration of TRIZ into the TQM implementation for the school district administration and public transportation. TRIZ was used to substitute the traditional brainstorming technique for idea generation. Unlikely, Hashemi (2004) believed that the integration of TRIZ and TQM can derive a new framework, Total Creativity and Innovation Management (TCIM), which can inventively solving all the problems including but not limited to quality problems within an organization. The author treated the TCIM as the results of integrating all of the current available TQM methods with TRIZ. Definitely, this wide integration of TRIZ and TQM demands more familiarity and acceptance of TRIZ throughout an organization.

The purpose of integration in the third category mostly focuses on enhancing the problem solving capability of TRIZ by absorbing other problem solving methods' strengths including inventive principle of nature (Bionical Engineering, BE), imagination for free association (Brainstorming, BS), divergent and convergent thinking (Creative Problem Solving, CPS), displaying and enhancing the search process for new ideas (MindMaps), creating the state of excellence for engineers (Neuro-Linguistic Programming, NLP), analogy for solving 5 levels of problem (Nakayama Masakazu, NM), and recognization of the different working modes of human brains (Six Thinking Hats). On the other hand, TRIZ may also have positive contribution to these problem solving skills. For example, TRIZ principles can be

utilized to improve the ratio of useful ideas to generated ideas in the idea generation phase of CPS (Hipple 2005). In this thesis, the integration of TRIZ and TOC TP is reviewed and discussed in detail.

4.2.2 TRIZ + TOC TP

The combination of TOC TP and TRIZ for the complex problem solving has received increasing attention. The thorough literature review finally revealed 18 contributions including 14 scholar articles (Conradie et al. 2005; Domb and Dettmer 1999; Domb and Kowalick 1997; Hua et al. 2006; Liu et al. 2008; Mann 2007b; 2007a; Mann and Stratton 2000; Moura 1999; Pfeifer and Tillmann 2004; Rizzo 1997; Stratton and Mann 2003; Stratton and Warburton 2003; 2006), 3 conference papers (Li et al. 2006; Liu and Tan 2004; Wei et al. 2008), and 1 dissertation (Luke 2002). For examples, Domb and Dettmer (1999) used TP to analyze the critical root cause of challenger accident, and used 40 inventive principles to generate non-compromising solutions. Li et al. (2006) integrated TP and TRIZ for idea generation during fuzzy front end of new product development.

Analysis of these articles showed that the most important synergy between TOC TP and TRIZ is that TP tools can replace or enhance the problem identification phase in TRIZ problem solving, and TRIZ inventive tools are powerful in developing innovative ways to remove the constraints identified by TOC TP. Moreover, the major studies emphasized the synergy between EC and TRIZ for contradiction elimination. The original purpose of EC is to identify the fundamental conflicts and resolve these conflicts in a non-compromising way by challenging the underlying assumptions. According to Domb and Dettmer (1999), EC is good at structuring and graphically

illustrating the critical elements of any conflict, but it is somewhat weak in generating ideas (called injections in TOC term) for resolving the conflict. Although Goldratt developed the idea of "alternative environment" to create injections, it is a difficult approach which can hardly help people to think of such an alternative situation (Conradie et al. 2005). Fortunately, TRIZ provides a systematic and structural approach which can overcome EC's weakness in stimulating idea generation. As shown in Figure 4-3, 40 inventive principles can be used for technical contradictions caused by two requirements, and 4 separation principles are utilized for physical contradictions depicted by two conflicting prerequisites. Several studies have discussed the details about the relationships between EC and TRIZ principles (Mann 2007b; 2007a; Mann and Stratton 2000).

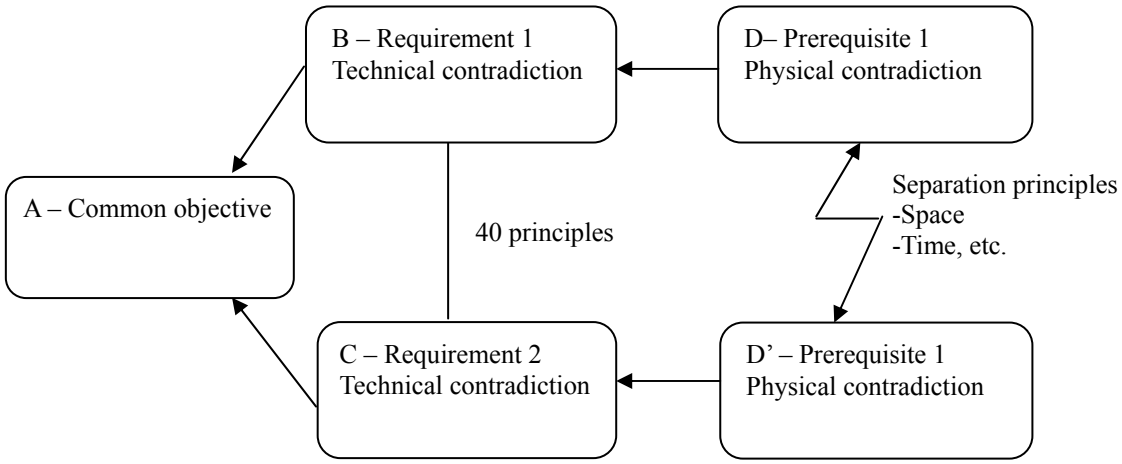


Figure 4-3: Synergies between EC and TRIZ Principles

Therefore, integration of TOC TP and TRIZ for problem solving usually adopts the CRT-EC-TRIZ process. Each tool respectively answers the questions: How do you know this is the problem? How do you know this is the right contradiction to solve? How do you find the right solutions to the contradiction? Specifically, this method starts with the UDE (Undesirable Effect)-specific CRT development to reveal the

effect-cause-effect relationships and locate the core problem. Once the core problem is identified by CRT, the next step is to construct EC to formulate fundamental contradiction behind the core problem, and then 40 inventive principles and/or 4 separation principles are used to generate innovative ideas for removing the contradiction. This method has been used in various studies for different purposes including challenger space accident (Domb and Dettmer 1999), forest harvesting problem (Conradie et al. 2005), new product development (Hua et al. 2006; Li et al. 2006; Liu et al. 2008; Liu and Tan 2004), and supply chain strategies (Stratton and Warburton 2003; 2006).

Although these studies demonstrated that CRT-EC-TRIZ method is effective in finding the critical problems, it still suffers from losing opportunities to generate enough good ideas. Moura (1999) stated that many studies only note the relationship between EC and TRIZ but ignore that CRT is also helpful to correctly formulate the mini-problems for TRIZ. Luke (2002) incorporated the ideas from TRIZ problem formulator and CRT into the "electrical schematic" logic diagram which retains the strength of idea generation of TRIZ and the advantage of focused design of TOC. In his study, the tool of EC was not adopted to prevent idea screening at the early stage. Meanwhile, almost all other valuable TRIZ tools can be selected, and thus it is more flexible than CRT-EC-TRIZ method that only utilizes 40 inventive principles and 4 separation principles.

On the other hand, a careful examination showed that all these studies focused on problems arising from the manufacturing industry. To date, application of integration of TOC TP and TRIZ in services has yet been explored. As previously discussed,

application of TOC and TRIZ in services is very limited, and thus it is not surprising to find no previous study regarding the integration of these two tools for services.

To summarize, the integration of TRIZ and TOC TP mainly focuses on the synergies between TRIZ principles and EC. The direct integration of TRIZ and CRT which enables the utilization of more TRIZ tools is seldom investigated. In addition, their integration is mainly used in the product design and manufacturing field. As TOC TP is applicable for any context, the integration of TRIZ and TOC TP can also be extended to services.

4.2.3 Conclusion

TRIZ has been integrated with many existing tools or methodologies to harness each other's strengths. Current integration of TRIZ with other tools is predominantly used in the product design and manufacturing field. This situation is attributed to the fact that almost all these tools are developed in the product design and manufacturing fields. However, some methodologies or tools are adaptive, and they can be used in any context. TOC TP and TRIZ are such two typical tools. Adapting and integrating them can overcome their own weaknesses, and provide more opportunities to address various problems in the service context.

4.3 Current Application of TRIZ in Service

TRIZ has been used by numerous companies around the world to solve technical problems, and it exhibits great power to creatively and systematically provide solutions. From the strategic perspective of new product development, TRIZ tools have been

used directly or together with other tools for different product development strategies, such as cost reduction (Liu et al. 2006), repositioning (Hentschel 2008), improvement to existing products (Mann 2000; Royzen 1998), product line extensions (Liu et al. 2006). As product is intimately linked to the process in which it is manufactured, TRIZ for design and improvement of production or manufacturing process has also received increasing attention (Poppe and Gras 2002; Srinivasana and Kraslawskib 2006).

On the other hand, several research works showed that TRIZ also exhibits its great potential of solving problems arising from non-technical fields such as business (Mann and Domb 1999; 2001; Ruchti and Livotov 2001), management (Mueller 2005; Takemura 2002), marketing (Movarrei and Vessal 2004; Retseptor 2005), politics (Klementyev and Faer 1999; Proseanic and Visnepolschi 2000), and education (Marsh et al. 2002; Marsh et al. 2004; Rivin and Fey 1997). However, application of TRIZ in these non-technical fields is still at an early stage. Among those non-technical fields, service also has very limited TRIZ applications. Current application of TRIZ in services can be generally classified into two categories. The first category is the adaption of TRIZ tools for services, aiming at interpreting the possible meanings of TRIZ tools with examples in services to facilitate the understanding of those tools. The second category is the application of TRIZ problem solving process and associated tools for service problems.

4.3.1 TRIZ Tools with Examples in Services

As TRIZ tools mostly originate from technical area, especially the product design and manufacturing area, they inevitably have some inherent technical characteristics which may limit their own applicability in services. Thus, some studies focused on

interpreting possible meaning of TRIZ tools with examples in the service context, expecting to help TRIZ users apply these tools more easily and accurately for solving service related problems.

Currently, the most examined TRIZ tool is 40 inventive principles. Zhang et al. (2003) provided examples from service operations to explain the specific meanings of the classic 40 inventive principles in the service context. Karni and Kaner (2007) absorbed some examples from previous studies in non-technical areas and derived a more fruitful examples of 40 inventive principles for services. Additionally, the authors also used contradiction matrix as an option to select these principles. However, the parameters in contradiction matrix are not explicitly explained in the service context.

To summarize, TRIZ tools have not been sufficiently studied in the service context. It is important and useful to adapt TRIZ tools for services. This adaption can make positive contribution to the innovation in services, and it also facilitates the application of TRIZ problem solving process in services.

4.3.2 Application of TRIZ for Service Problems

TRIZ problem solving process provides a structured approach to generate innovative solutions. This problem solving process and tools have been utilized for solving various service problems.

Zhang et al. (2005) formalized the TRIZ-based service conceptual design process, and applied it to generate new concepts of service operations in a university canteen. Chai, et al. (2005) also applied this process to redesign the sightseeing service on Singapore

Sentosa Island. Both of these two studies stressed TRIZ's ability to provide innovative solutions without compromise.

Karni and Kaner (2007) utilized TRIZ tools including 40 inventive principles and contradiction matrix to the service system design. They built up a three-level service system taxonomy which decomposed the general service system into basic elements. Then, TRIZ techniques can be applied to a service system design in the same way as technical system design, i.e. the identified contradictions due to the conflicting elements within a service system can be solved by using the contradiction matrix and 40 inventive principles. The authors also linked all the elements directly to the derivatives of 40 inventive principles in the service context. Therefore, when an element is conceptualized during the service system design, associated TRIZ principles can be easily retrieved to generate satisfactory or even innovative design solutions. They applied their method to design an after-sales service facility to demonstrate the effectiveness of their method.

Su et al. (2008) applied 40 inventive principles and contradiction matrix to improve the e-service quality for an e-commerce company. They pointed out that the proposed new ideas overcome the experience and knowledge limitation of the managers in that company.

In summary, all these studies highlighted the TRIZ's idea generation and innovation capability for services. Although TRIZ was applied to the service concept, service system, and service quality problems, no previous study of applying TRIZ for service process has been found.

4.3.3 Conclusion

TRIZ, a powerful methodology, has not been widely applied in the service context. One of the reasons is that it is difficult for beginners to master; another reason is that the lack of interpretation of TRIZ tools in the service context increases the difficulty for users to select the right items in TRIZ toolbox. Several studies have contributed to the application of TRIZ in services, but further studies are still very demanding.

Chapter 5 Framework Building

The framework is based on integrating TOC TP and TRIZ. TP performs the function of problem identification with convergent thinking, while TRIZ provides the function of innovative problem solving. The process of this framework is to use these tools in a sequential but complementary manner. Meanwhile, the process of this framework is supported by the studies including the revised ranking method for choosing root causes, adaption of TRIZ tools in the service context, and improved way of integrating TP and TRIZ. Finally, this framework will be applied to improve various service processes. Figure 5-1 illustrates the framework, and the step-by-step instructions are described below.

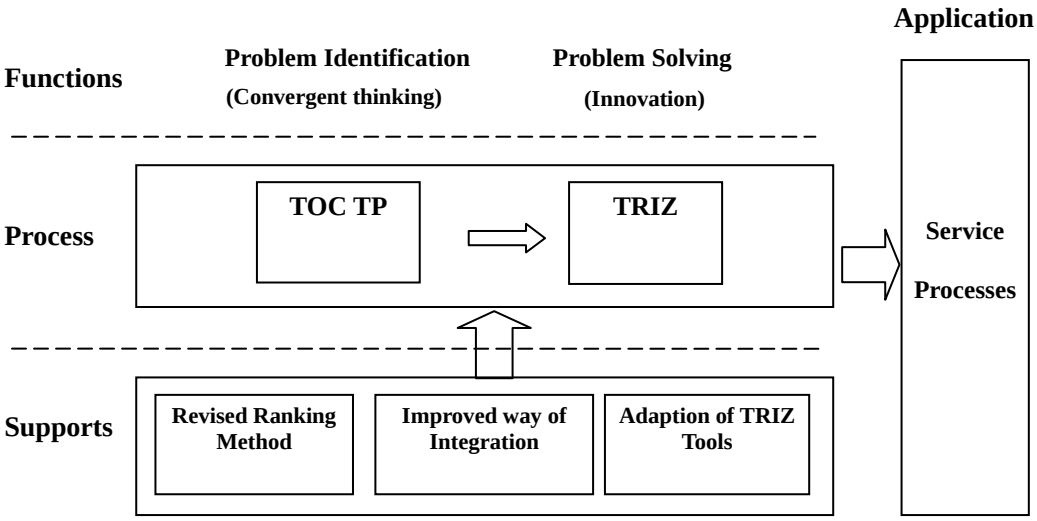


Figure 5-1: Framework for Service Process Improvement

5.1 Step 1: Analyze the Process and Related Problems

Although a service organization usually provides a series of services to their customers, we can only focus on one specific service and its related process at one time. The aim of this step is to provide background of the target service process and the main

problem, and to collect necessary information for the further problem solving process.

Step 1.1: Describe the target service process.

The target service process needs to be described in a clear way. Clear understanding of the target service process can help to identify the possible problems and develop solutions.

Step 1.2: Verbalize the goal of improvement.

The IFR is used to describe the goal of improvement in this sub-step. Usually, the improvement goals are stated in a compromising manner which discourages breakthrough thinking. IFR can help overcome this limitation. To formulate the IFR, we can answer the question, "If there is an ideal state of the process, what are the characteristics it has?" Four basic characteristics of IFR provided by Domb (1997b) can also serve as guidelines to formulate IFR:

(1) Eliminates the deficiencies of the original system

(2) Preserves the advantages of the original system

(3) Does not make the system more complicated (uses free or available resources)

(4) Does not introduce new disadvantages

To conclude, the first step mainly aims to describe the target service process, and to collect the relevant information regarding the service process and the main problem. This step provides the foundation for the deep analysis by TOC TP tools in the next step.

5.2 Step 2: Construct Current Reality Tree

Step 2.1: Identify important undesirable effects (UDEs) which relate to the main problem and the service process defined in step 1;

UDEs are visible results that are negative in relation to our goal or the necessary conditions to achieve that goal. The UDEs reflect the symptoms of a few underlying causes, and they act as the gateway to finding the real problems. According to Shoemaker and Reid (2005), an UDE has six characteristics:

(1) A complete statement,

(2) An effect (not a presumed cause) that there is some possibility of changing,

(3) Something that exists in today's reality precisely as stated,

(4) Negative or undesirable in its own right,

(5) Not a presumed solution, and

(6) A single effect with no *and, because, due to, or as a result of* phrases needed to clarify

However, UDEs are subjective to some extent. The undesirability is related to an individual's own concept of "negative" (Dettmer 1997). Therefore, it is important to confirm the improvement goal and decide who will benefit from the improvement and whose viewpoint is the most important for reaching that goal. Then, the UDEs must be identified from the viewpoint of those pertinent people. For example, Shoemaker and Reid (2005) formulated the customer-oriented goal which stressed the vital role of client services and customer satisfaction, and thus they identified UDEs mostly from the customer's complaints and front-line employee's issues. Reid and Cormier (2003), on the other hand, analyzed the situation mainly from the owner's perspective to reach the goal of reducing the owner's workload.

To determine the UDEs, service problems or issues can be collected through observing the service process and interviewing the pertinent people like managers, employees, and customers. Then, the UDEs can be identified through analyzing, simplifying, and consolidating those problems. To simplify CRT construction and further analysis, it is appropriate to retain maximally five to ten major UDEs as the start points.

Step 2.2: Rank UDEs according to the severity priority number (SPN);

As CRT does not focus on severity or ranking but on effect-cause-effect relationships (Taylor et al. 2003; Taylor and Thomas 2008), traditional method regards the root cause which results in the largest number of UDEs as the core problem. However, UDEs are not equal to one another. Some UDEs are clearly more undesirable than the others. Traditional ranking method does not incorporate this information into analysis, and it does not offer any suggestion about how to handle the situation when the most burning UDE is not caused by the core problem. Dettmer (1997) indicated that it is the common sense that you cannot ignore the UDE that bothers you the most. Scheinkopf (1999) also suggested that users should strategically determine whether they should solve the root cause which accounts for 70% of all UDEs or solve the root cause which induces the most serious UDE. These studies suggest that both effect-cause-effect relationships and severity of UDEs are important for users to determine the core problem. Therefore, this study tries to incorporate the severity information into our analysis by starting with ranking UDEs according to SPN.

Pertinent people are required to rate the degree of severity (S) and frequency of occurrence (O) for each UDE in the scale from 1 to 5. That is, for severity rating, 1

means the least severe, and 5 means the most severe; for the occurrence rating, 1 means the least likely that the UDE will occur, and 5 means the most likely. The data can be collected by questionnaires (see Appendix D). Finally, the severity priority number (SPN) can be calculated by multiplying the arithmetic average of severity and occurrence rating scores, as shown in Equation (5-1)

$$SPN_i = S_i \times O_i \tag{5-1}$$

Step 2.3: Construct the current reality tree according to the procedure provided by Scheinkopf (1999)

(1) Determine the scope of analysis;

(2) Select 5 and 10 worst UDEs that exist in the system, and subject each of these UDEs to the entity existence and clarity reservation;

(3) Diagram the effect-cause-effect relationships that exist among the UDEs;

(4) Review and revise for clarity and completeness;

(5) Apply to "So What Test" to ensure all the UDEs are pertinent entities.

In conclusion, the second step mainly aims to identify the specific problems. Unlike the first step where the main problem is described in a very general form, this step utilizes the logic tool of CRT to establish the effect-cause-effect relationships, aiming to drill down from symptoms to root causes.

5.3 Step 3: Identify the Directions for Improvement

Step 3.1: Identify all the root causes;

Although all entities with only coming out arrows are generally recognized as root causes, we need to trim the entities which are not involved in connecting the UDEs

with each other, because they are irrelevant to our analysis. Meanwhile, some entities are the fact of life (FOL), which is not controllable and changeable by the users. These types of entities will not be treated as root causes. After the trimming process and FOL examination, all the real root causes can be identified.

Step 3.2: Rank the root causes according to revised ranking method;

For each root cause that is retained in the CRT diagram, we should determine the extent to which it is responsible for the existence of UDEs. As mentioned in step 2.2, our approach includes both the effect-cause-effect relationships and the severity information of UDEs to calculate the weight of a root cause. As shown in Equation 5-2, the weight of the root cause *i* is calculated by summing up the SPNs possessed by the relevant UDEs that root cause *i* can produce.

$$W_i = \sum SPN_j \tag{5-2}$$

Step 3.3: Select the root cause having the highest weight, and identify the directions for improvement by the improved way of integration;

As mentioned in literature review, traditional way of integrating TP and TRIZ adopts CRT-EC-TRIZ process, i.e. CRT reveals the complete effect-cause-effect relationships among entities, and helps to determine the core problem as the focus of improvement; then, EC is used to formulate the core problem into the core contradiction which can be further resolved by TRIZ contradiction elimination tools. Solving this contradiction often leads to the most effective solutions to the original problem.

However, not all the root causes can be easily formulated into conflicts or contradictions by EC. Therefore, this study develops an improved way of integration.

Users should examine if the selected root cause can be formulated as a core contradiction by EC. If yes, then the EC will be used to clarify the core contradiction, and TRIZ contradiction elimination tools will be selected to remove the contradiction in the next step. If no, then the TRIZ problem modeling tools including problem formulator, Su-Field Analysis will be used to formulate the root cause into a mini-problem. Accordingly, corresponding TRIZ tools will be selected to solve the mini-problem in the next step.

In conclusion, the third step is to determine which root cause is our current target. Meanwhile, based on the specific situation, this step will decide whether we should eliminate a contradiction or solve a mini-problem in the next step.

5.4 Step 4: Generate Solutions to Contradictions or Mini-Problems

Step 4.1: Apply contradiction elimination tools to remove the technical and/or physical contradictions;

The typical contradiction elimination tools include contradiction matrix, 40 inventive principles, and 4 separation principles. To obtain good solutions, users should try to intensify the two conflicting elements of the identified contradiction to two extreme situations.

To apply 40 inventive principles and 4 separation principles in the service context, users may refer to 40 inventive principles and 4 separation principles with application examples in services (Chai et al. 2005; Zhang et al. 2003). Meanwhile, to facilitate users to understand the contradiction matrix in the service context, this study tries to provide the possible meanings of 39 generic parameters in the service context (see

Appendix A).

It is also very helpful to examine whether other TRIZ tools will help the problem solving and idea generation. Take the TRIZ resource tool for example. One of the underlying principles of TRIZ is the full utilization of resources. That is to say, before introducing new resources to the system, TRIZ requires full utilization of all the existing resources. The resources can be substances, space, and time contained within or around a system's environment. Usually, contradictions could be solved by those existing resources which are hidden from problem solvers. This principle is consistent with the TOC management philosophy. TOC requires that the next step after the constraints being identified is not to rush to elevate the constraints by adding new resources or capacities, but to exploit the constraints, i.e. to maximize the operation efficiency of the constrained resources within the system. However, although TOC philosophy emphasizes this point, it does not explicitly provide practitioners with any procedure or tool to systematically identify the resources in the system. Fortunately, this is the exact area where the TRIZ resource tool is powerful.

Step 4.2: Model the mini-problem and solve it accordingly.

TOC TP narrows down the original problems into very specific ones. It is possible that the solutions to the mini-problem are very direct and obvious. Actually, for many real world problems, it is very difficult to find the effective solutions just because we do not know what we should focus on.

On the other hand, it is also highly likely that the solutions of some mini-problems are not obvious, thus we still need to model them by TRIZ problem modeling tools such as

problem formulator and Su-Field Analysis. As the problem scale has already been reduced, we can derive solutions without much effort. To facilitate the Su-Field Analysis, this study provides the interpretation of Su-Field Analysis with examples in the service context (see Appendix B). Finally, if the problem is still very hard to solve, Algorithm for Inventive Problems Solving (ARIZ) will be chosen to help derive solutions.

In conclusion, the final step aims to generate solutions for the convergent problems by TRIZ tools. According to the problem situation identified by the previous step, different TRIZ tools could be chosen to effectively generate ideas. Finally, the whole process is illustrated in Figure 5-2.

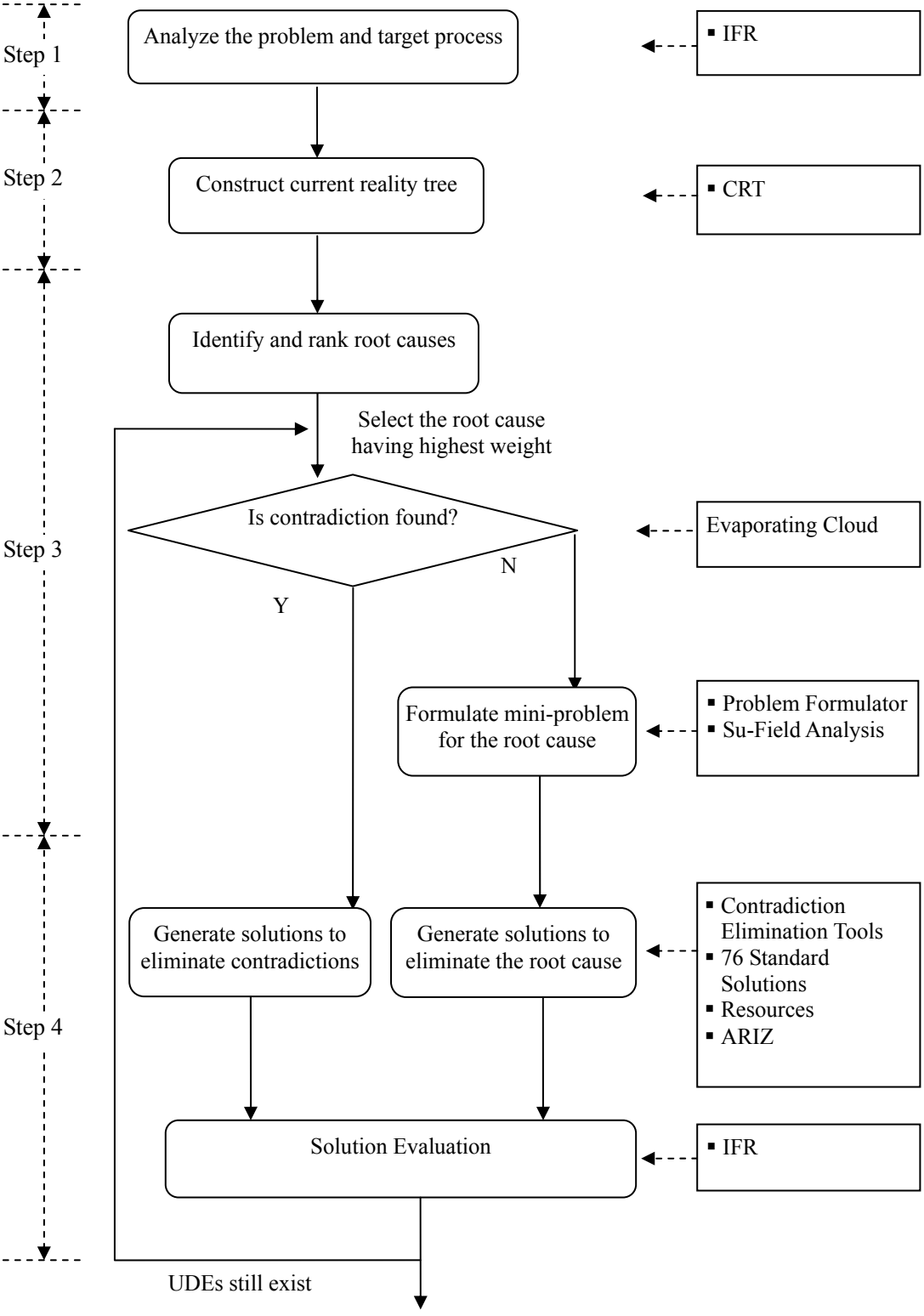


Figure 5-2: Process of the Conceptual Framework

Chapter 6 Research Methodology

6.1 Research Design

This research was deployed in 2 phases. The main task of phase 1 is to collect common problems within restaurant service processes from web survey and literature review. As the main task of phase 1 is to collect the basic information instead of completing more complex tasks like hypothesis testing, time and resource were controlled in a rather limited range. Compared with traditional surveys, web survey has several advantages, including shorter transmitting time, lower delivery cost, more design options, and less data entry time. The data collected from these two sources were synthesized into a list of common problems. The output of phase 1 and the results from the second literature review were utilized to design the interview questionnaire of phase 2.

Phase 2 is the core of this research project. This phase collects the data of specific problems and other information such as process information, improvement goals, and resource limitations. As this thesis in an exploratory study, case study is an appropriate research methodology (Yin 2003). Moreover, case study research allows researchers to examine contemporary real-life situations and provide the basis for the application of ideas and extension of methods. It can be used for the purpose of theory testing and theory extension/refinement (Voss et al. 2002). As shown in literature review, theory background for TRIZ and TOC in services is limited. Therefore, case study methodology will not only enable the testing of proposed framework in the real world, but also encourage the future improvement to the proposed framework through the feedback generated from the chosen case studies.

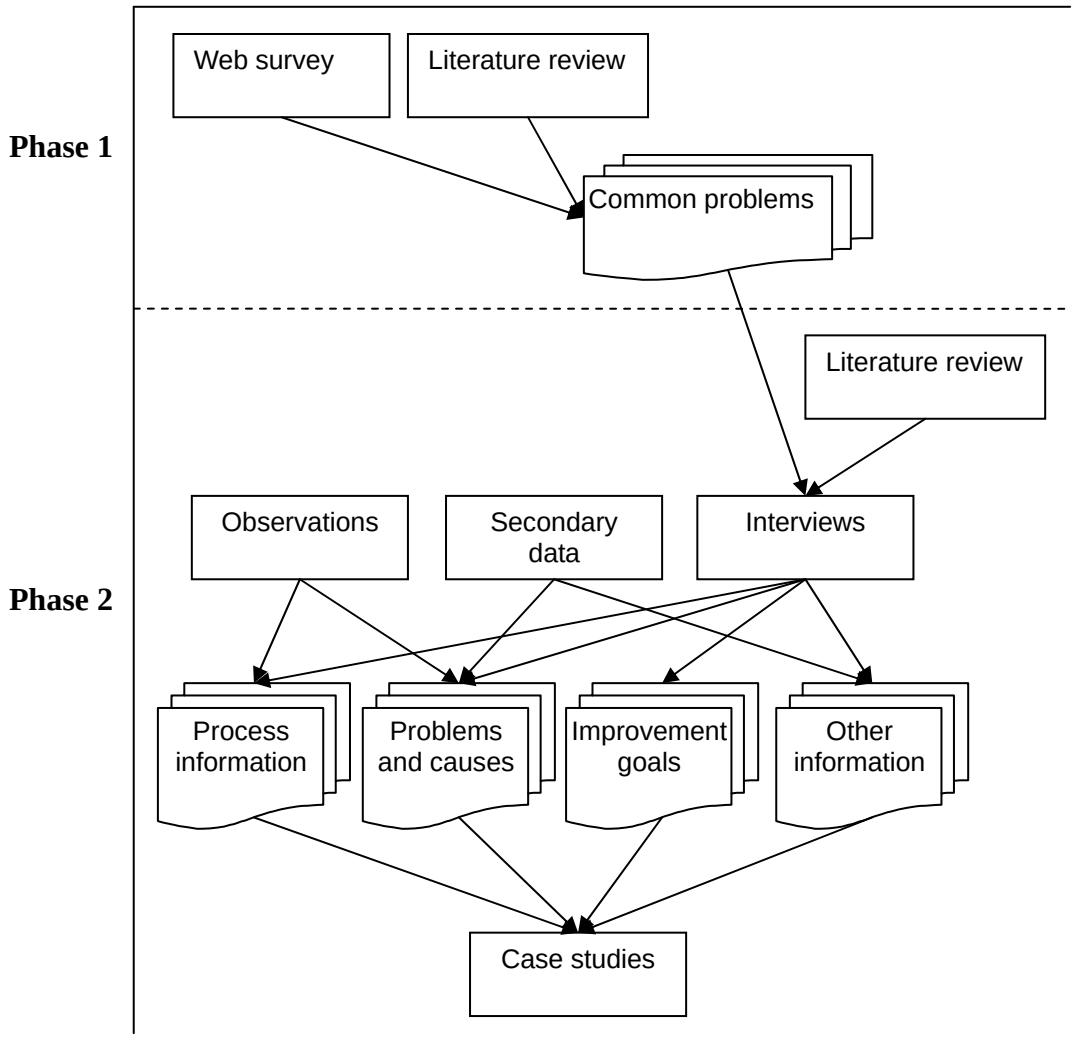


Figure 6-1: Research Design

The sample consists of five Chinese casual dining restaurants in Singapore. According to demographic statistics in 2009, the Chinese formed 74 percent of the resident population in Singapore (SingStat 2009). Meanwhile, the tourism statistics from Singapore Tourism Board (STB) indicated that the visitor from China is the second largest visitor-generating market in Singapore for the past 5 years (STB 2008). Food is also promoted by the STB as one of several compelling reasons for visiting Singapore. Therefore, to better cater for this largest segment of customers, it is necessary to improve service processes in Chinese dining restaurants and offer customers the first-class dining services. Although this approach may limit the research

generalizability, it permits us to gain a much deeper understanding and increases the reliability of the findings. The scale of case restaurants ranged from small to medium operations, and types of case restaurants covered normal casual dining, buffet style, and fast casual dining.

Case studies were performed through semi-structured interviews, direct observation, and analysis of secondary sources (such as corporate websites, online customer review). Using different data sources can help ensure the internal consistency of data and reliability of a case study (Voss et al. 2002; Yin 2003). All the data collected from each restaurant were synthesized to build a CRT which forms the basis of a complete case study. Figure 6-1 shows the research design.

6.2 Phase 1 – Common Problems

6.2.1 Data Collection

As mentioned in the previous section, the primary data collection method of phase 1 is web survey. Web survey was conducted online on www.surveymonkey.com. As the web survey is to collect common problems, anyone who is able to access internet and has experienced services in restaurants could be our respondent. The survey questionnaire asked respondents to choose and/or write down the problems they experienced in certain stages of a service process (the web survey questionnaire can be found in Appendix C). For example, respondents can choose the problems they encountered during reception, order placement, food serving, and payment in the restaurant service process. Other problems such as car parking problems were not covered in this questionnaire. Table 6-1 lists some facts of web survey data collection.

Table 6-1: Web Survey Data Collection

What	Data type	Why collect	How to collect
Common problems	Qualitative	Understand the common problems or symptoms in a certain type of service process (Hotel, Healthcare, and Restaurant). The result will be the groundwork for the mail survey.	Respondents will be asked to choose and write down the service failures, problems they have experienced during service processes.

Literature review is to find and analyze the articles related to subjects of service failure, service quality, and process improvement. The literature review retrieved journal articles from ABI/Inform (ProQuest), Elsevier Science Direct, and Emerald Insight with the keywords of "service failure, service quality, or process improvement" and keyword of "restaurant". The retrieved articles were carefully examined, and the problems discussed in these articles were extracted and recorded.

6.2.2 Data Analysis

The data analysis for phase 1 mainly focuses on listing all the collected problems, and removing the duplicated items from web survey and literature review. The response count for a certain problem can be treated as an indicator of the importance of that problem.

6.3 Phase 2 – Cases

6.3.1 Data Collection

In phase 2, the primary data collection method was the semi-structured interview. The interviews mainly treated service managers (operations, customer service, or quality

managers) as the respondents, as they usually have overall clear understanding of the whole service processes, improvement goals, and other useful information within their organizations. As defined in chapter 2, a service process consists of a part of partners' activities and a part of customers' activities and all activities related to the service within a company. To improve a service process in a systematic way, each interview asked questions covering the service process itself and the related management activities. Typically, the interview asked the service problems related to process quality dimensions including reliability, assurance, tangible, empathy, and responsiveness. The customer complaint is an important source to identify this kind of problems. In addition, the interview asked problems which were related to the managers' goals of process improvement. Therefore, additional problems covered the fields of service recovery, process design, employee recruitment, cost reduction, and marketing activities.

The semi-structured interviews used audio-record device to record each interview sessions. When the interviewees were unwilling to have the conversation recorded, we took notes to record the whole session. During an interview session, interviewee(s) were required to answer some designed questions (A sample interview questionnaire can be seen in Appendix D, and some questions were accordingly modified for each interview session) as well as some more specific probing questions based on their answers to the designed questions. Meanwhile, the online customer review/complaints were presented to interviewees to examine their validity. Naturally, interviewees were willing to answer some neutral questions or share their successful experiences, but they were reluctant to unveil the problems existing in their restaurants. To encourage their information provision, we explained the purpose of this study and informed them that

all information provided would keep confidential. In addition, the online customer reviews/complaints also served as probing questions if they hesitate at the beginning. Finally, direct observation to the service process in a restaurant helped to gain more insight into the actual process and possible problems which were not identified by managers.

Table 6-2: Interview Data Collection

What	Data type	Why collect	How to collect
Problems	Qualitative	Identify the problems in a service process of a certain service company.	Respondents will be asked to choose and write down the problems they have experienced or perceived during a service process.
Improvement goals	Qualitative	Clearly determine the goal of improvement	Respondents will be asked to choose or write down the expected improvement goals
Resource limitations	Qualitative	List the resource limitations to improve the service process. These limitations may be overcome by TRIZ breakthrough thinking.	To solve these problems or symptoms. (such as lack of physical resources, human resources, knowledge)
Causes	Qualitative	Partially understand the possible causes for each symptom, and help to determine the effect-cause-effect relationship	Respondents will be asked to write down the possible causes for the 10 main symptoms identified.
Degree of severity	Quantitative	Obtain the severity information of 10 main symptoms, and use this information to calculate the severity priority number of UDEs	Respondents will be asked to rate in the scale 1-5
Frequency of occurrence	Quantitative	Obtain the severity information of 10 main symptoms, and use this information to calculate the severity priority number of UDEs	Respondents will be asked to rate in the scale 1-5

All of the data collected from an individual interview, related secondary data source,

and direct observation were synthesized and analyzed. Then, the data analysis led us to a comprehensive understanding of the whole service process and related problems, and helped to complete the CRT building and solution generation. Table 6-2 lists more details of the interview data collection template.

6.3.2 Data Analysis

The data analysis for phase 2 focused on forming individual case studies. Information collected from each interview session were synthesized and treated as the basis of a case study. Some information was carefully analyzed as follows.

Improvement goals: the original goals may be stated in a compromising way, which may discourage the breakthrough solutions. To overcome this limitation, this study used IFR to restate the improvement goals.

Symptoms and causes: this part of information is the core data of this study. The data collected from each interview session were used to identify UDEs in a service company, and the analysis stage started to build CRT from the UDEs. The collected causes helped to determine the effect-cause-effect relationships in building the CRT. The degree of severity and frequency of occurrence of UDE were used to calculate the Severity Priority Number (SPN) for each UDE. After the CRT was completed, the SPN and the effect-cause-effect relationships were used to calculate the weight of each root cause according to the revised ranking method.

Other information: Other useful information such as management style, marketing strategy, employee profile, and resource limitation could also partly contribute to the

building process of effect-cause-effect relationships. Moreover, during the solution generation, the collected resource limitation in a specific service company was examined to determine if they really affect the solution's feasibility. It is possible that these resource limitations which prevented service companies from improving their processes can be broken by TRIZ tools.

Chapter 7 Results and Implications

7.1 Phase 1 – Results

Table 7-1 lists the survey result of common problems in restaurant service process. The web address of the survey questionnaire was sent to author's current classmates and former classmates. Finally, the web survey invited 40 people and received 10 responses from the customer's viewpoint in one month. The most frequently mentioned problem focuses on the long waiting time for table. Actually, all customers have experience of waiting for a seat in a restaurant, especially in a full table service restaurant. Waiting time for table is not avoidable in the restaurant service process. The process design, employee efficiency, service capacity, and physical comfort in waiting areas influence customer's actual waiting time and customer's perceived waiting time.

Table 7-1: Survey Result of Restaurant Service Process

Problem	Response count
Receptionists with poor attitude	4
Long waiting time for table	10
Reservation missing	1
Waiters with poor attitude	4
Long waiting time for order placement	5
Employees' lack of knowledge	6
Items on the menu are sold out	7
Waiters with poor attitude	3
Food defects	7
Long waiting time for food	8
Food not cooked to order	5
Order misplaced or never filled	1
Casher with poor attitude	3
Unclear, guest unfriendly policies	8
Incorrect charges	2

The waiting time for food is also unavoidable due to the similar causes. As the waiting time for food is relatively short in a fast food restaurant, the problem of long waiting time for food is in the second place. Unclear or unfriendly guest policy is also in the second place. This problem often occurs when a restaurant only accepts cash but rejects other ways of payment. This policy is adopted by some restaurants to avoid additional facility investment and charges from the credit card company. However, it brings inconvenience to their customers especially those tourists.

The third place is the quality problem of core services including food defects and availability. Some often-cited food quality problems included delivering cold dishes, unfavorable taste, dishes not fresh, and limited variety. Food quality is often deemed as a fundamental component to satisfy and retain restaurant customers, but it belongs to result quality which is the order-qualifying criterion. Therefore, most quality-related studies in restaurants focused on the process quality attributes and often overlooked the food quality (Namkung and Jang 2007). Although food quality does not belong to the process quality, the possible causes of food quality problems may include those process problems such as process inefficiency and variations in food preparation, and supporting activities problems such as inappropriate inventory management and employee training. Food availability was also often mentioned by respondents. Certain dishes may be unavailable to customers due to the inappropriate demand forecasts, poor inventory management, and cost cutting policies.

Employee's knowledge of the menu items is also a big concern in restaurant services. It is generally considered as an assurance item. A new customer often needs relevant information about certain food items or recommendations directly from the contact

employee, so he/she can decide whether he/she will order them. It will be a disappointment when the contact employee cannot elaborate on the ingredients and features of certain food items. Meanwhile, employee's knowledge of the menu items is also related to measures of responsiveness, as knowledgeable contact employees are able to effectively respond to customer requests or questions. Employee's lack of knowledge may result from the insufficient training provided to new employees and lack of training time due to excessive demands compared to the service capacity.

The next problem is related to the order fulfillment including long waiting time for order placement and food not cooked to order. Waiting time for order placement can be considered as a measure of responsiveness, loaded with the measure of empathy. Sometimes, a customer cannot place an order because it is difficult for them to receive individual attention from employees even they are available. This problem may result from the inefficient process, insufficient training provided to employees, and mismatch between the service capacity and demands. Food not cooked to order is related to a measure of reliability, that is to say, services are not provided as promised. This problem may result from the process design, employee errors, and communication problems between contact employees and customers.

The rest problems focus on contact employee's poor attitude which is related to the measures of empathy. These problems may involve rudeness, inappropriate verbal communication, and indifferent behaviors. Employee's service attitude may be influenced by factors such as training, work load, management support, and customer behaviors. Problems including reservation missing, incorrect charge, and order loss are amidst the least frequent service failures.

Most of the problems identified from the literature were the same to the results of web survey, although they may also discuss additional problems related to tangibles (Pete et al. 1995) and employee issues (Reid and Cormier 2003) (see Table 7-2).

Table 7-2: Other Problems Cited from Literature

Problem	Author(s)
Unreadable menu	(Pete et al. 1995)
Untidy dining areas	
High employee turnover rate	(Reid and Cormier 2003)

The menu design and the number of appropriate items on a menu can partially affect the customer's evaluation of food quality. Clear menu design provides a good media for customers to learn about the food and may reduce the workload of contact employees for explaining menu items for customers. Too many items on a menu may reduce the readability of the menu, and can also complicate the food preparation process and raw material management in a restaurant. Untidy dining areas can significantly affect the customer's emotional evaluation of food quality, and it may result from the mismatch between the service capacity and demands or inappropriate manpower scheduling. The high employee turnover rate is not a direct process quality problem, but it adversely affects employee performance, because there are often not enough employees to provide services to customers and new recruited employees are more inclined to make mistakes.

Although these problems identified in this phase may not be an exhausted collection of common problems in the restaurant service process, they provided background for the questionnaire design and interview sessions for the next phase study. Based on the results of phase 1, phase 2 studied individual restaurants which had a part of these

problems in their service process.

7.2 Phase 2 – Results

7.2.1 Case Study 1

Introduction:

Restaurant A is a casual dining chain restaurant which offers a range of Chinese cuisines. The restaurant is decorated with charming timber facade and wooden tables and chairs which provide customers with dining experience reminiscent of ancient Chinese village inns. Restaurant A is a small operation with 19 full-time employees and seating capacity of 60 customers. With the goal of providing excellent customer services experience, the management places strong emphasis on the quality of food and service to achieve the highest customer satisfaction. To enhance employees' service skills and motivate them to deliver high quality service, the management provides monthly in-house trainings and courses to their employees and inculcates a sense of family and team spirit among them, thus resulting in high employee job involvement and low employee turnover.

Process description:

The service process of restaurant A is very common in the restaurant industry. The service process includes queuing outside for dining table, greeted and ushered in by a waitress, placing orders, having meals, and finally making payment. In general, service quality in restaurant A has reached a level at which most customers are very satisfied. Customers can receive prompt and polite services. The goal of the service process is to achieve the highest customer satisfaction.

Problem analysis:

However, there are still some customers complaining unsatisfactory services they received. The problems are related to the slow service recovery speed after service failures occur. In restaurant A, when a service failure occurs and a customer complains, contact employees will adopt the established service recovery routines which they learned from the training courses. This policy is clear for contact employees and it is also effective for most of the service failure situations. However, when an exceptional situation happens, contact employees usually cannot handle appropriately rather than report to their duty manager and wait for manager's direction. Sometimes the duty manager is too busy to provide prompt response, letting the customer waiting for a long time. Moreover, in some cases, even the duty manager does not have the right to take suitable actions to recover a service failure. He will apologize to the customer, and then report the issue to the corresponding office in corporation headquarters, and wait for the feedback. Since a restaurant is a place where customers tend to stay for a relatively short time, customers may leave the restaurant without problem being solved. Meanwhile, negative information has a greater impact on cognitive structure and attitude than positive information, thus poorer service recovery tends to be more memorable over time (Hoffman et al. 1995). The unresolved problem and bad memory may lead to a breakdown in the relationship between a customer and the restaurant, thus generating negative word of mouth and future behaviors.

CRT construction:

The corresponding CRT is shown in Figure 7-1. This case has only one UDE, i.e. customer receives slow or even no service recovery. The identification number for each entity is arbitrarily assigned. The identification number of UDE is preceded and

followed by two stars (**NNN**). After examining each entity in the CRT, the final CRT reveals that the root cause of the UDE is that contact employees do not have autonomy to deal with exceptions when a service failure happens. When an exceptional service failure happens and a customer complains to a contact employee, what the employee can do is to apologize and give some explanations. Su-Field Analysis can be used to model this root cause. The contact employee and customer are substances, S1 and S2 respectively, in the Su-Field model, while the interaction between them represents the field F. The complete model is shown in Figure 7-2.

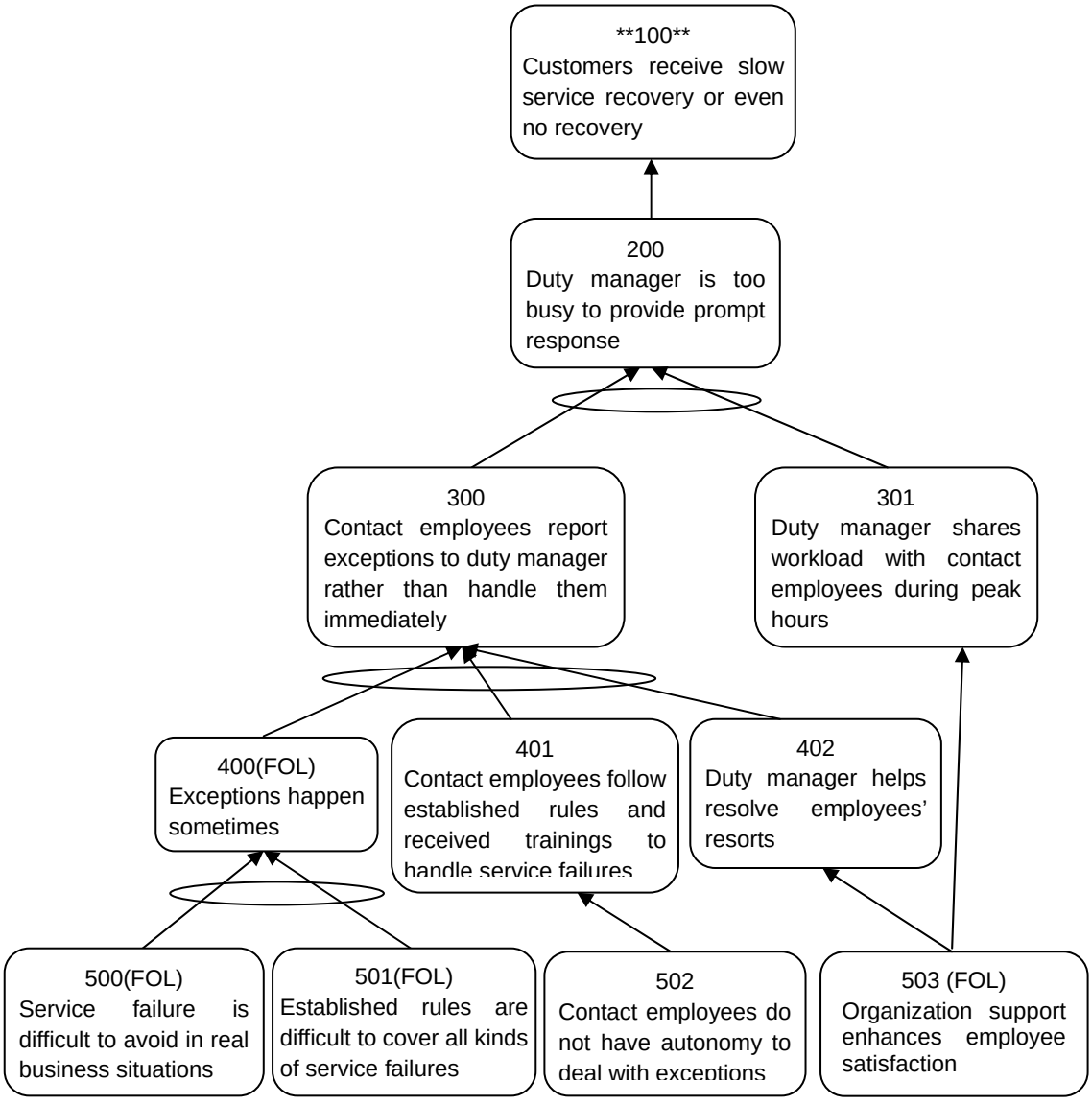


Figure 7-1: Current Reality Tree for Restaurant A

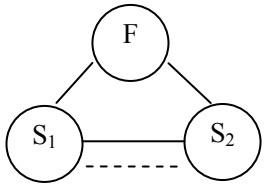


Figure 7-2: Su-Field Model for Root Cause in Restaurant A

Problem resolution:

Current problem presented by this model is that the existing field is not sufficient to provide useful interaction between two substances. Referring to the generalized solutions in Appendix B, abstract solutions can include modifying one of existing substance, modifying the existing field F, and adding new field between two substances. Therefore, the specific solutions to this problem are:

- Increase the segmentation of one or both of the substances. Customers can be segmented based on their relationships with the restaurant. The VIP customers and the frequent customers are given the priority to have their non-routine service problems being recovered without management intervention. Exceptional service problems from relatively new customers are recovered by apologies and management intervention. Meanwhile, as they may not receive prompt responses except immediate apologies, managers can consider offering some kinds of compensation to them.
- Enhance the current field. Contact employees should response as soon as possible when a service failure occurs to reduce the customer waiting time for recovery. Apologies along with appropriate explanations for the service failure should be provided in the first place before reporting the issues to the duty manager.
- Add new field. Contact employees can have rights to offer some forms of monetary compensation such as discount on food items or coupons redeemable

in the subsequent visits. This solution requires that the management empowers contact employees so that they can make on-the-spot decisions.

In fact, these three solutions all depend on employee empowerment, which allows contact employees to make their own decisions on how to handle exceptions. Restaurant A has already established continuous training and learning culture. Meanwhile, management also provides organizational support to their employees such as helping them during peak hours, accepting their feedbacks on service improvement. All these measures have resulted in the employee's high job involvement and job satisfaction, which turn into their good service orientation skills. Hence, to go a step further in improving process quality, management can consider giving employees more discretionary power to actively handle service recovery rather than delegating limited authorities to employees according to their levels in the organizational hierarchy.

These three proposed solutions are not mutually exclusive. Instead, they should have better effect if used together. According to the justice theory, success of service recovery depends on three aspects: distributive justice, procedure justice, and interactional justice (Blodgett et al. 1997; McColl-Kennedy and Sparks 2003). The distributive justice is related to the monetary compensation in the proposed solutions, procedure justice concerns the prompt response from contact employees instead of management intervention, and the interactional justice is in line with the sincere apologies and appropriate explanations. From the justice theory, all three aspects of justice should be achieved to make customers feel they have been treated fairly. Therefore, restaurant A could re-think its service recovery policies by increasing the employee empowerment to have customers to feel that they can be treated fairly

whenever a service failure happens, thus realizing service recovery paradox (Matos et al. 2007) rather than double deviation (Ok et al. 2007). In this case study, although the proposed solutions can be explained by the justice theory, management can have a much clear picture about the effect-cause-effect relationships concerning current problems by using our proposed approach. Management knows clearly about what our root causes are and where the root causes locate. Moreover, the proposed approach can also be applied to other areas which cannot be solved by the justice theory.

7.2.2 Case Study 2

Introduction:

Restaurant B is a traditional Shanghai eatery which has history dating back over a century. The restaurant has expanded internationally with branches mainly in Asia countries including South Korea, Japan, Singapore, and Malaysia. The case restaurant in this thesis is one of Singapore branches which started its operations in 2005. The restaurant was re-decorated in 2008 with a unique interior theme that features the iconic bamboo basket used for steaming buns. The improved interior decoration enhances the customer's dining experience in Restaurant B. The main customers of Restaurant B include those workers working in nearby areas and some families who often visit on weekends.

Most of the managers and waitresses are local Singaporeans or permanent residents who are bilingual in English and Chinese. Chefs are hired from the branch restaurant in China, while the other kitchen staff are hired from both local and China job markets based on their technical skills. Currently, Restaurant B is a relatively small restaurant, with seating capacity of 50 customers. The employees in Restaurant B include 25

full-time workers and 2 part-time workers. The employees are hired through various recruitment channels including placing advertisements on newspapers, online job portals, agent, and employee referral scheme. Regular training is provided to employees to ensure their service level is maintained at a standard level. The restaurant manager takes charge of two restaurant branches in Singapore, and almost equally allocates his working time for those two branches.

Process description:

The service process of Restaurant B is very common in the restaurant industry. The service process includes queuing outside for dining table, greeted and ushered in by a waitress, placing orders, having meals, and finally making payment. The goal of the service process is to achieve customer satisfaction and increase the profit margin.

Problem analysis:

The direct observation and interview help to identify several UDEs that need to be eliminated to improve the current service process so as to achieve higher customer satisfaction and increase the profit margin.

1) Customer complains about the seating problems. As a small restaurant, the total space of restaurant B is very limited. To increase the seating capacity, restaurant B maximizes space utilization by squeezing as many small 2-seater square tables as possible. This kind of tables and chairs are made of wood. As the tables are rather small and very close to each other, many customers find it is too cramped to sit at tables and the tables are too small to fit their dishes. On the contrary, to accommodate families or customers in a big group, restaurant B also has 5 sets of sofas located near

the window, and each set can generally serve 4-6 persons. It is much more cozy and spacious than 2-seater tables. As restaurant B intends to maximally reduce the seating vacancy rate and customer queuing time, 2 or fewer customers coming together will be allocated to a 2-seater table. Many customers want to change their tables to sofa when there is an empty one, but the waitress usually refuses their requests without sincere explanation.

2) Customer waits for long time during the peak hours. During the peak hours, there is a long queue for dining table. Some customers may quit the long queue when the waiting time becomes unacceptable for them. Usually, during their dining time, some customers order additional dishes or require employees to clear empty plates and clean their dining tables. However, they may have to wave their hands many times or wait for a relatively long time until a waitress notices and serves them. Four facts are identified as the reasons resulting in the above problem. Firstly, contact employees are not scheduled according to the peaks and troughs of customer demand. There is an obvious overlap between employees' dining time and customers' dining time, thus resulting in insufficient employees to provide prompt services and pay enough attention to customers. Secondly, as the two-seater tables are too small to hold many plates or bamboo baskets, customers may frequently ask employees to clean their tables and clear empty dining ware. This increases employees' work load and actually keeps the on-duty employees always busy, and thus they inevitably lose attention to some customers. Thirdly, the manager tends to use loose control style to manage subordinates. As the manager put "I have to treat my subordinates as well as customers and give them support, otherwise they may transfer the bad attitude to our customers." The manager allocates appropriate number of employees and adjusts it according to

customer demand, and he also works with them to provide services to customers or help employees to handle difficult issues. Employees have relatively high loyalty to restaurant B under this management style, and they can also provide relatively good services to customers. However, as aforementioned, the manager has to travel between two branches. When he is not in this branch, employees tend to be uncontrollable, and sometimes the employees hang at the end of the dining area, chatting and ignoring the existence of customers, so customers have to try very hard to draw their attention. Lastly, the manager also pointed out that some customers in sofas tend to stay and chat for a long time even though they have finished their meals. Spacious and comfortable, the sofas are occupied by some customers as an ideal place for resting and chatting. This phenomenon decreases the table turn rate and keeps other customers waiting for tables.

3) Dining environment is noisy. Customers complain that the dining environment is too noisy during the peak hours. Usually, customers in Chinese restaurant tend to chat with friends when they are having meals. Moreover, as mentioned above, the space is very cramped in restaurant B, and customers can easily and clearly overhear the conversation from adjourning tables. Meanwhile, employees sometimes also chat aloud, and deteriorate the dining environment.

Rank UDEs according to the severity priority number (SPN):

During the interview, manager gave the estimates of degree of severity and frequency of occurrence for each UDE. The severity priority number (SPN) for each UDE is calculated according to Equation 5-1 and shown in Table 7-3.

Table 7-3: SPN Calculation for Restaurant B

	Degree of severity	Frequency of occurrence	SPN
UDE1	3	3	9
UDE2	2	3	6
UDE3	2	2	4

CRT construction:

From the identified UDEs and their causes, the corresponding CRT is built and shown in Figure 7-3, Figure 7-4, and Figure 7-5. The three-digit entity identification numbers have been arbitrarily assigned. The three main UDEs are entities whose identification number is preceded and followed by two stars (**NNN**). From the current reality tree, three root causes have been identified.

Root cause 1: restaurant B wants to be successful – this root cause is related to contradictions.

Root cause 2: manager uses loose control style to manage employees.

Root cause 3: overlap exists between employee's dining time and customer's dining time.

Rank the root causes according to revised ranking method:

CRT reveals the full effect-cause-effect relationships between UDEs and root causes. For example, it can be seen from CRT, root cause 1 is associated with all three UDEs. Table 7-4 shows the detail of these relationships.

Table 7-4: Relationships between UDEs and Root Causes in Restaurant B

	RC1	RC2	RC3
UDE1	✓		
UDE2	✓	✓	✓
UDE3	✓	✓	

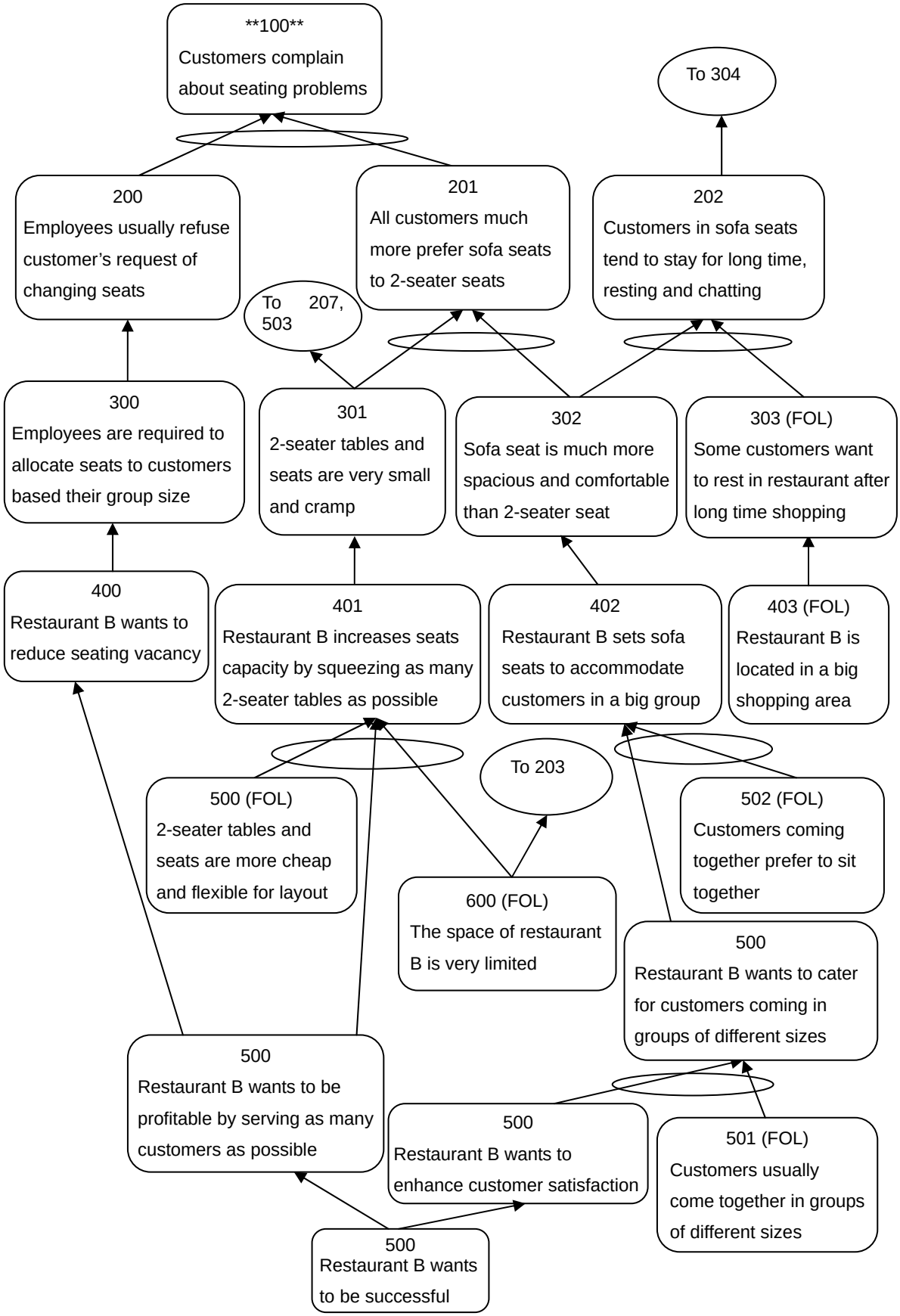


Figure 7-3: Current Reality Tree for Restaurant B – Part 1

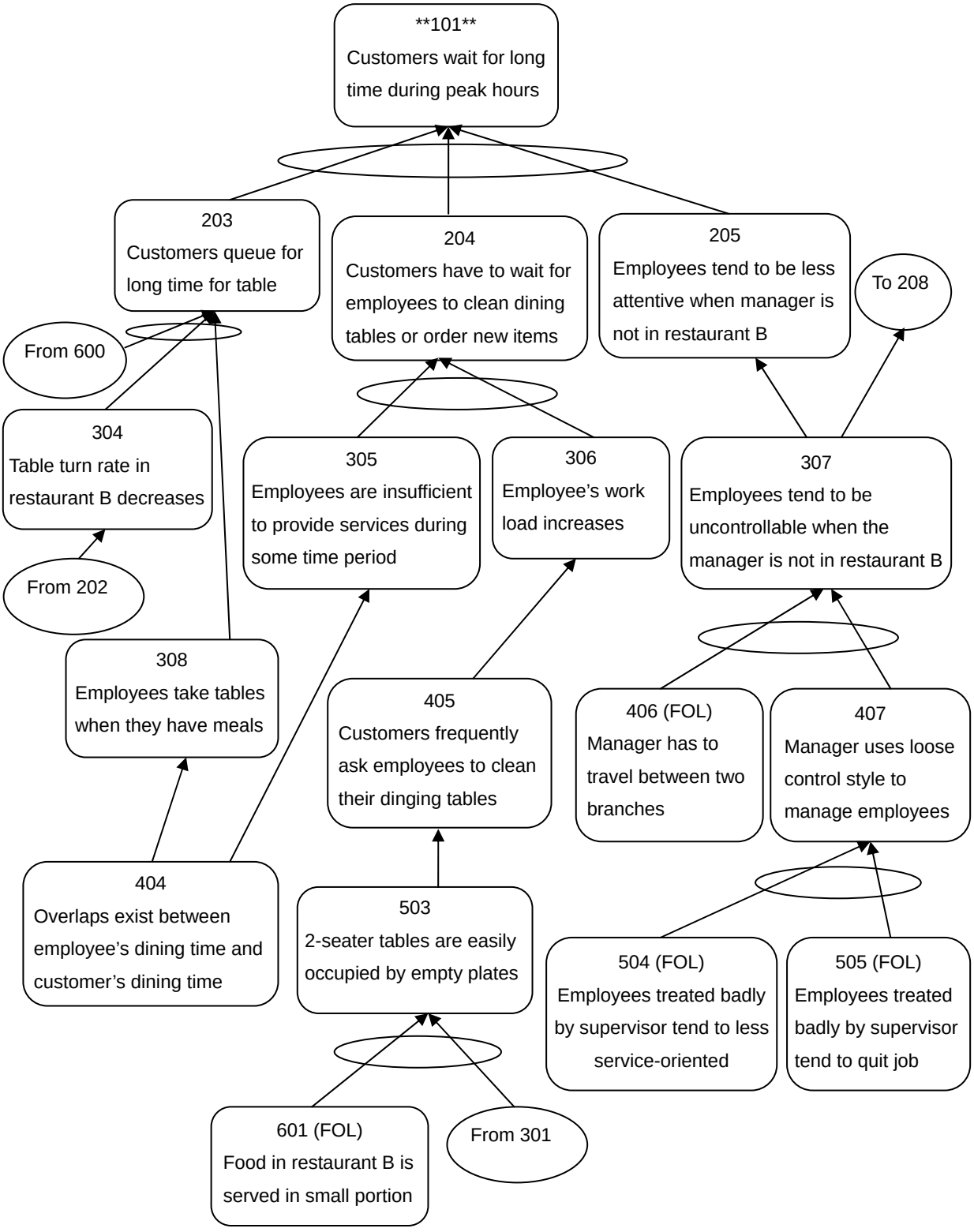


Figure 7-4: Current Reality Tree for Restaurant B – Part 2

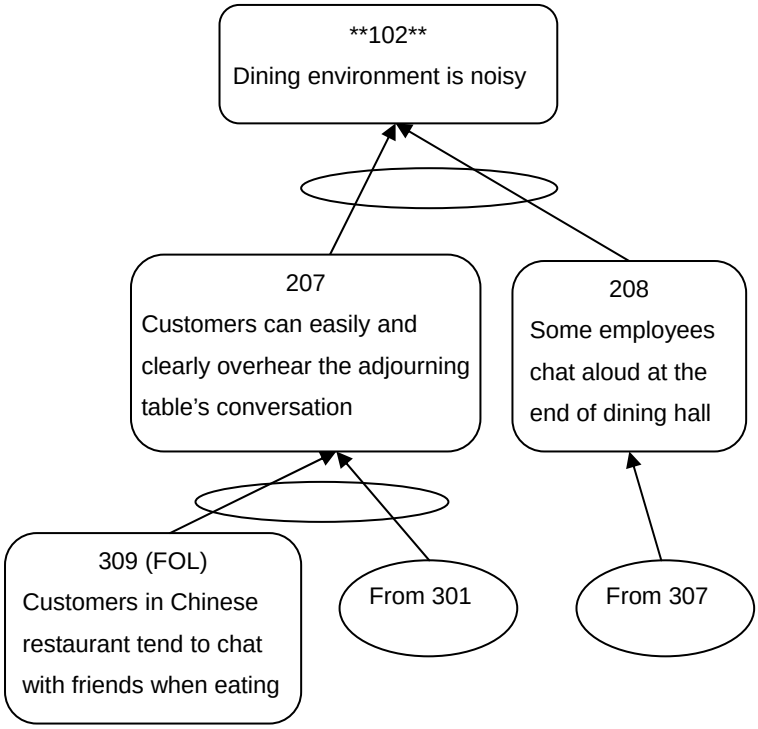


Figure 7-5: Current Reality Tree for Restaurant B – Part 3

As described in chapter 5, the relationships along with SPN for each UDE are used to calculate the weight of each root cause according to Equation 5-2. The results are shown in Table 7-5. From the results, we can see that the first root cause is the most important one that needs to be eliminated. The root cause of loose management style is at the second place, while the root cause of overlaps in dining time, compared to other root causes, is the least important one.

Table 7-5: Weight Calculation for Each Root Cause in Restaurant B

$\mathbf{W_{RC1}}$	9+6+4 = 19
$\mathbf{W_{RC2}}$	6+4 = 10
$\mathbf{W_{RC3}}$	6

Problem resolution:

The first root cause can be expressed in a contradictory manner by EC (see Figure 7-6). On one hand, restaurant B wants to increase its profit margin by maximally utilizing its limited space, so it has to squeeze as many 2-seater tables as possible to accommodate the huge amount of customers during the peak hours. The 2-seater tables are cramped and relatively uncomfortable. One the other hand, restaurant B recognizes that customer satisfaction is the only way to retain customers and gain long-term benefits. To achieve customer satisfaction, restaurant B should provide more spacious and comfortable sofas to customers. However, sofas occupy much more space than 2-seater tables do.

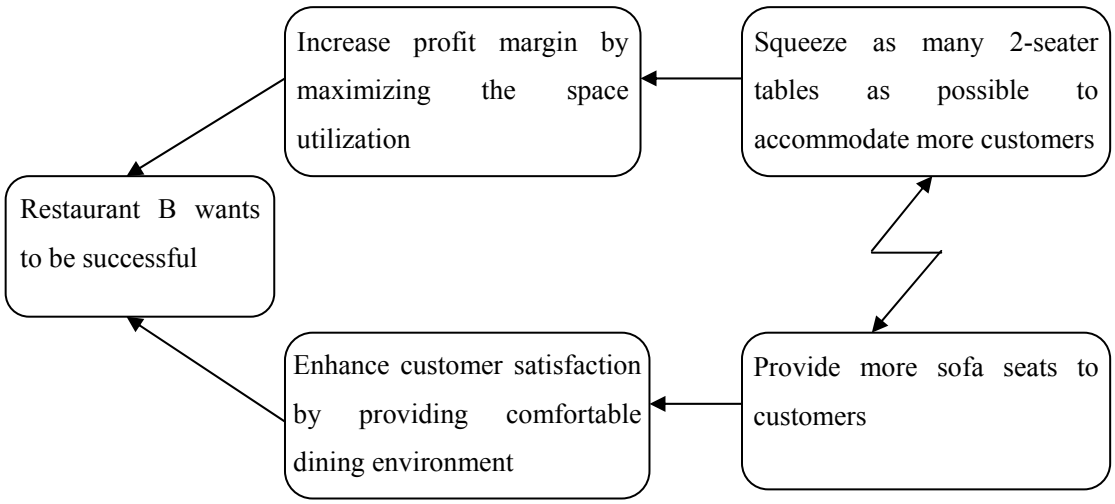


Figure 7-6: Evaporation Cloud 1 for Restaurant B

To solve this contradiction, we may first consider the technical contradictions represented by two requirements: productivity versus volume of binding object. The parameter of productivity represents the first requirement of increasing profit margin by maximizing the space utilization, while the volume of binding object represents the second requirement of increasing seating space to provide comfortable dining environment. Improving in productivity will worsen the volume of binding object. According to contradiction matrix, the suggested principles are 35-parameter changes,

37-thermal expansion, 10-preliminary action, and 2-taking out. By examine these principles, we can derive two solutions.

- Principles of parameter change. Restaurant B can change the original 2-seater wooden seats to 2-seater sofa seats which can provide better comfortable dining environment. This measure will partly decrease the customer's requirements for large sofa seats, making them feel that they are treated fairly to some extent.
- Principle of thermal expansion. Restaurant B can use the adaptable sofa seat which can be separated into small sofa seats. When customers come in a big group, they can be arranged to a complete sofa seat. When customers come in a small group, they can be arranged to a small sofa seat that is taken out from a complete sofa seat. This solution can also be recognized as the derivatives from the principle of segmentation.

These two solutions require that restaurant B should invest on the facilities and stop operations for a few days. The manager pointed out that the restaurant currently lacks money to invest on facilities and re-design of the layout. The management prefers to make some improvement without any cost incurred. By incorporating the consideration of financial limitation, we re-establish the contradiction which is shown in Figure 7-7.

The contradiction is caused by the way in which the sofas are allocated to customers. As it is more comfortable than a wooden seat, most customers tend to require a sofa seat whenever they visit restaurant B, but restaurant B strictly allocate the seats based on the group size. This contradiction can be solved by using separation principles.

- Separation in time. When a small group of customers comes during the peak hours, a contact employee could guide them to a 2-seater table as usual.

However, if they require changing tables to sofas, the contact employees should provide sincere apologies and clear explanation to them why the restaurant cannot change seats for them now. In this way, most customers will understand and accept. When a small group of customers come beyond the peak hours, a contact employee can also guide them to a 2-seater table as usual. If they require changing seats, the contact employee should arrange them to the sofas. To implement this solution, employees should show more initiative to provide appropriate actions. Some employee training is required from the manager.

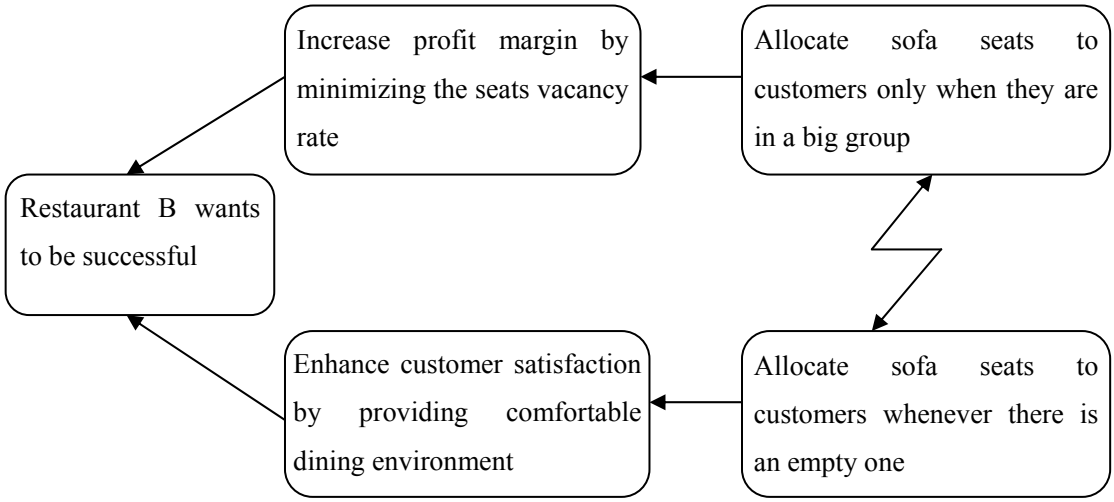


Figure 7-7: Evaporation Cloud 2 for Restaurant B

The second root cause is related to manager's loose control style of managing his subordinates. We use Su-Field Analysis to formulate this problem. The manager and employees are substances, S1 and S2 respectively, in the Su-Field model, while the interaction between them represent field F. The complete model is shown in Figure 7-8.

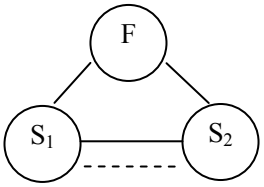


Figure 7-8: Su-Field Model of Root Cause 2 in Restaurant B

Presented by Su-Field model, the problem associated with the root cause is that the field is not sufficient to provide useful interaction between two substances. Referring to Appendix B, the solution can be modifying one of existing substances, modifying the field, or expanding existing Su-Field model to a chain. The details of specific solutions are presented in Table 7-6.

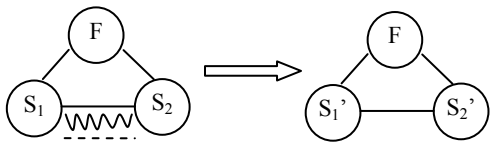
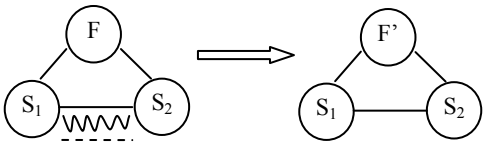
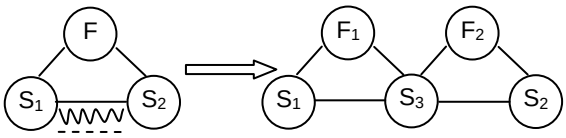
From the Su-Field Analysis, we propose three possible solutions. The management of restaurant B can choose more than one solution, and they can use a combination of these solutions to the problems caused by the loose control style.

However, it should be noted that the proposed solutions may also create harmful effects. For example, hiring employees with high qualification usually costs restaurant more money. Since restaurant B is a relatively small operation, the human resource cost should be carefully examined. The solution of "manager visit branch in arbitrary time" actually may result in difficulties for the manager to schedule works, thus increasing the workload of the manger.

Currently, the solution of appointing an assistant manager could be the best one. Although the salary cost for the assistant manager may increase, the promotion and corresponding cash rewards could also bring the employee loyalty to restaurant B,

Meanwhile, the workload of manger can be alleviated, and, more importantly, the employees' customer focus can be improved even the manager is not in this branch.

Table 7-6: Solutions for Root Cause 2 in Restaurant B

Su-Field Solutions	Specific Solutions
	Restaurant hires employees with high qualification in service orientation skills and improved awareness of customer focus. Manager can manage the employees in the same loose control style as before to provide respect and support to them.
	Manager changes his management style in a more controllable style. The field could be made dynamic, i.e. the manager can visit branch at arbitrary time other than fixed time.
	Manager appoints an assistant manager or a supervisor in this branch, so he can delegate management tasks to the assistant manager when he is not in this branch. Importantly, the manager should empower the assistant manager, and gives him more autonomy to deal with the daily management issues.

The third root cause is related to the overlap between employee's dining time and customer's dining time. This problem results in not only insufficient employees but also insufficient dining seats during the peak hours. Meanwhile, as employees have

their meals in sofa seats, some customers who request changing seats but are refused by employees are much more unsatisfied, as they feel that they are unfairly treated. This root cause can be formulated by Su-Field Analysis. The employee and customer are substances, S1 and S2 respectively, in the Su-Field model, while the interaction between them represents the field F. The complete model is shown in Figure 7-9.

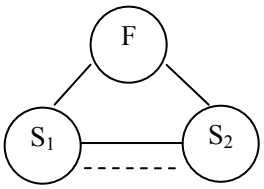


Figure 7-9: Su-Field Model of Root Cause 3 in Restaurant B

By analyzing this root cause, we can conclude that the problem can be presented as the rhythms match, i.e. the frequency of field F partially matches the frequency of substance S2. Referring to Appendix B, we can see the generalized solution can be mismatching the rhythms. The generalized solution is presented in Figure 7-10. Specifically, the restaurant B should arrange the employee dining time completely beyond the peak hours. Actually, the number of employees in restaurant B is more than that in restaurant A (27 versus 19), even though its space and seat capacity are less than restaurant A. The work efficiency could be much improved if all employees can work during the peak hours, and even the part-time employees will not be needed.

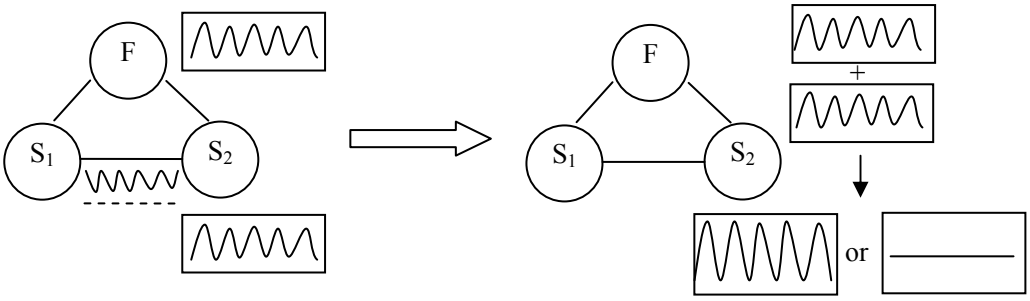


Figure 7-10: Generalized Solution for Root Cause 3 in Restaurant B

Summary

Built upon several UDEs, the logic diagram CRT helps to understand the necessity relationships underlying the conflict and three root causes associated with various UDEs. The revised ranking method is used to determine which conflict or root cause is more urgent for management to address. Then, the conflict is presented in a contradictory manner by EC. Then, the conflict is solved by TRIZ contradiction elimination tools including contradiction matrix, 40 inventive principles and 4 separation principles. And other two root causes are eliminated by using Su-Field Analysis. The proposed solutions for restaurant B should be examined by its management to decide which one has the first priority to be implemented.

7.2.3 Case Study 3

Introduction:

Restaurant C is a Chinese casual dining restaurant which serves a wide spectrum of buffet Cantonese dim sum. Unlike traditional concept of buffet where food is cooked beforehand and customer can select what they want in a single meal, restaurant C serves buffet in the way similar to the full table service. Customers can order what they want from two menus, a dim sum menu and a main dishes menu. Kitchen staff then prepares food for customers according to their orders. They do not prepare food in advance or have their staff pushing the trolley around to offer dim sum. Therefore, freshness and quality of food can be guaranteed. In addition, restaurant C also offers breakfast on the weekends from 8:00am in the morning although it is not the main business.

Restaurant C is located in an office building by the side of Orchard road which is the retail and entertainment hub of Singapore. The surrounding area, known as Orchard, is a major tourist attraction which has numerous shopping malls, restaurants, and hotels, and it is frequently visited by the local people and foreign tourists.

Restaurant C is a relatively large operation with seating capacity of 200 customers. Restaurant C mainly hires employees from local job market by posting advertisement on newspapers and purchasing services from commercial recruitment agencies to hire foreign workers from China. It now maintains 12 full-time employees including managers, waiters, and kitchen staff. Restaurant C divides working hours into 2 shifts on the weekdays to cater customer demands in two relative busy periods. 1 or 2 part-time employees are available to help out during the lunch time on weekends.

Process description:

The service process of restaurant C is very similar to normal restaurants, but it also has some differences. The service process includes queuing outside for dining table, greeted and ushered in by a waitress, placing orders, having meals, and finally making payment. As restaurant C severs buffet, customers certainly place orders many times during a single meal. In addition, customers pay a fixed fee instead of a variable fee based on what they have chosen before they leave. The goal of the service process is to achieve customer satisfaction and increase profit margin.

Problem analysis:

The observation and interview help to identify several UDEs that need to be eliminated to improve the current service process.

1) Long waiting time for food. In restaurant C, a customer can repetitively order their favorites from more than 50 different menu items in a single meal. As mentioned before, the kitchen is very busy in preparing items after they receive orders. Frequently, a customer can wait for more than half an hour or even longer time for certain items. The first cause of the long waiting time is the huge number of menu items. As the manager said, 'customers at one table usually order up to 9 items in a normal restaurant, but they prefer to order as many kinds of items as possible in buffet style restaurant. Our kitchen staff are always busy in preparing a wide variety of food, repetitively.' 50 different selections cannot be regarded as many in a normal buffet restaurant where the food is pre-prepared and customers take any available food. However, it operates in the way like the full table service, and food is prepared in small quantities. This operation manner requires preparation of many different materials, use of many different cooking procedures, and frequent set-up of equipments, resulting in the waste of time and significant increase in the number of kitchen jobs.

2) The profitability decreases. The profitability of the restaurant C has been decreasing for recent years. The most important reason is that the customer loss increases due to two reasons. Firstly, many customers are not satisfied because of the long waiting time as mentioned above, so customer retention is negatively affected although service employees are friendly and courteous. The majority of customers are those who hold loyalty and become the VIP members of restaurant C. Restaurant C offers certain discount to those customers to encourage their re-patronage. However, as the number of similar Chinese restaurants gradually increases in recent years, some existing

customers with unsatisfactory experience reduce their re-patronage rate or even switch to other similar restaurants.

Secondly, the location of the restaurant C makes it difficult to attract new customers. Although the surrounding area is a major tourist attraction in Singapore, restaurant C is situated in an office building which is not noticeable for most citizens and tourists. As the Orchard area is full of numerous shopping centers and hotels with numerous different types of built-in food courts and restaurants, most people prefer to choose the nearest dining place rather than seek a restaurant in a relatively out-of-the-way place. Although restaurant C is not far from a subway station, there are several big shopping centers with numerous built-in food courts and restaurants. Before customers reach restaurant C, they often choose other dining places in the middle way. Therefore, it is difficult for the restaurant to attract new customers. As the manager put, 'when we look through the window, we see people walk through, and never come in this building or go upstairs to our restaurant.'

3) Some customers waste food. In buffet style restaurants, it is often inevitable that some customers pick too much food, resulting in the waste of food. Therefore, almost all buffet style restaurants surcharge the customer who cannot finish food in their plates. This measure requires customers to take the precise amount of food which they are able to eat up, thus helping restaurants to reduce waste. However, it is very difficult to put this measure in practice. As the manager said, 'we indeed have this regulation, but it is really not what we want to control. It is difficult to judge if a customer wastes food as they may left a little in every plate, but there will be a whole plate of food wasted in total. Meanwhile, it is often unacceptable to argue with a customer in front

of many other customers. ’ One cause of this UDE is also related to the number of menu items and the way in which restaurant C operates the buffet. A customer may order as many kinds of food items as possible in a buffet. When the buffet is self-service style, the customer can try a certain item he/she has not had before, and then he decides whether it is his/her taste. In this way, the customer can avoid taking too much unfavorable food. However, in restaurant C, a customer cannot control the portion of a food item as it is served in the full table service style. Therefore, the customer may find a certain item is not his/her taste, but he/she has to finish it any way according to the regulation. However, in this situation, he/she is highly likely to waste some food and even question the food quality.

Rank UDEs according to the severity priority number (SPN):

During the interview, manager gave the estimates of degree of severity and frequency of occurrence for each UDE. The severity priority number (SPN) for each UDE is calculated according to Equation 5-1 and shown in Table 7-7.

Table 7-7: SPN Calculation for Restaurant C

	Degree of severity	**Frequency of occurrence**	**SPN**
UDE1	4	4	16
UDE2	3	3	9
UDE3	2	4	8

CRT construction:

From the identified UDEs and their causes, the corresponding CRT is built and shown in Figure 7-11 and Figure 7-12. The three-digit entity identification numbers have been arbitrarily assigned. The three main UDEs are entities whose identification number is preceded and followed by two stars (**NNN**). CRT reveals the full

effect-cause-effect relationships between UDEs and root causes. Two root causes are responsible for three UDEs.

Root cause 1: restaurant C wants to achieve customer satisfaction – this root cause is associated with contradictions.

Root cause 2: restaurant C lacks proper marketing measures to publicize itself.

Rank the root causes according to revised ranking method:

It can be seen from CRT, root cause 1 is associated with all of the three UDEs, while root cause 2 is related to the second UDE. Table 7-8 shows the details of these relationships.

Table 7-8: Relationships between UDEs and Root Causes in Restaurant C

	RC1	**RC2**
UDE1	✓	
UDE2	✓	✓
UDE3	✓	

According to the revised ranking method, the relationships along with the SPN for each UDE are used to calculate the weight of each root cause. The final results are shown in Table 7-9. From the results, we can see that the first root cause is the most important one that needs to be eliminated. Actually, the first root cause is far more important than the second root cause.

Table 7-9: Weight Calculation for Each Root Cause in Restaurant C

$\mathbf{W_{RC1}}$	16+9+8 = 33
$\mathbf{W_{RC2}}$	9

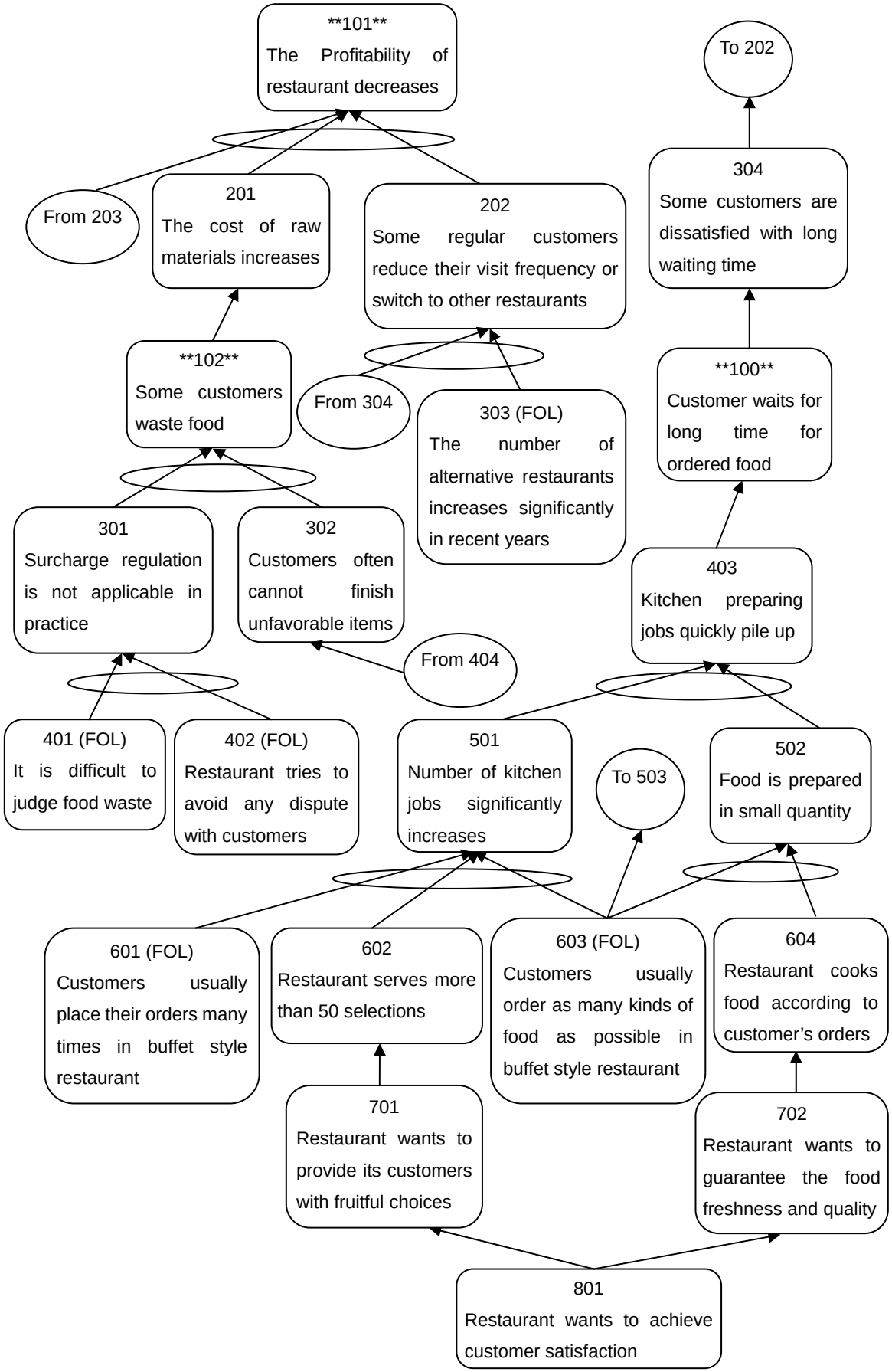


Figure 7-11: Current Reality Tree for Restaurant C – Part 1

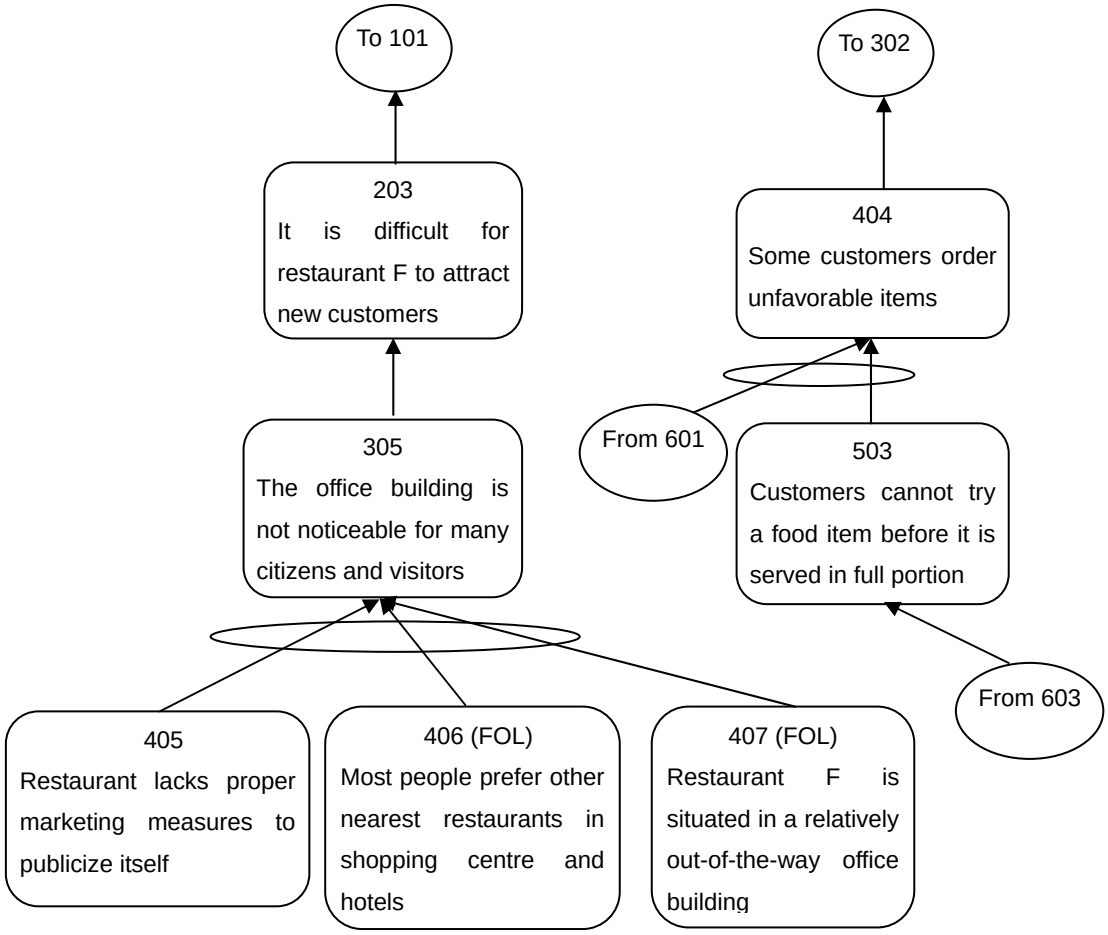


Figure 7-12: Current Reality Tree for Restaurant C – Part 2

Problem resolution:

The first root cause is related to a contradiction which can be represented by EC (see Figure 7-13). On one hand, restaurant C wants to provide as many selections as possible to fulfill customer demands. To achieve this objective, kitchen staff is busy preparing many kinds of raw materials every day, and the different procedures required by different food items also increase their workload. It is often impossible to timely prepare many kinds of food items during the peak demand hours, and thus many buffet restaurants stick to the way of 'making to stock' in which food is pre-prepared in a certain amount before customers place order. However, this way of food delivery cannot ensure the food freshness and quality. To guarantee the food quality and freshness, restaurant C adopts the similar way as the full table service in which the

type and quantity of food are determined by customer orders. In summary, food is prepared in the way of "making to order", and food is delivered hotly and freshly. However, as food should be prepared in small batches, kitchen jobs quickly pile up.

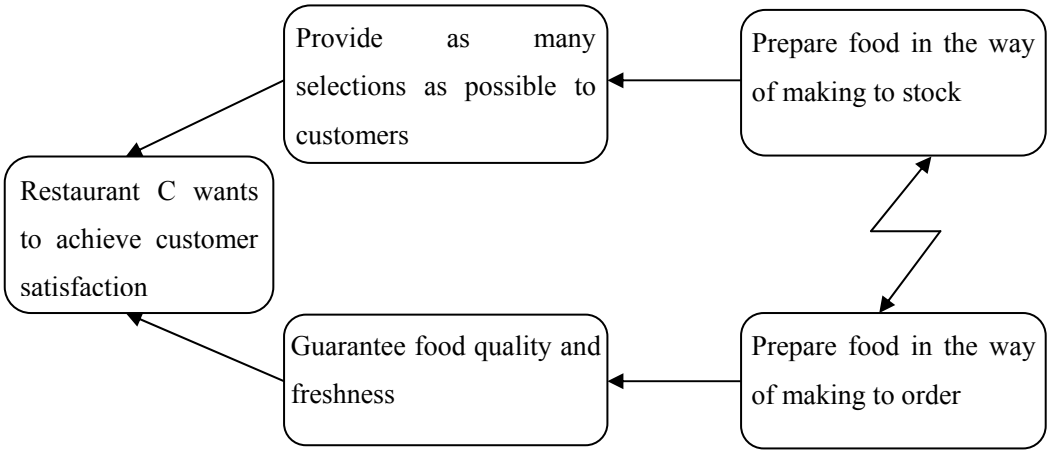


Figure 7-13: Evaporation Cloud for Restaurant C

To solve this contradiction, we consider 4 separation principles and 40 inventive principles to generate following possible solutions.

- Separation in whole and parts. Most of the food items can be prepared in the way of making to order. However, parts of food items which customers frequently order can be prepared in the way of making to stock. Restaurant C should collect statistical data regarding customer orders. The order frequency of each food item can be calculated. The final numbers are used as one of important standards to determine the way of preparing food items. Generally, food items with high order frequency can be made to stock. In this way, customers can receive fresh items in time, and kitchen staff can prepare these food items in large batches, thus reducing their backlog of cooking jobs.
- Beforehand cushioning. Restaurant C currently adjusts its service capacity by adopting shift work and hiring part-time employees. Considering the operation

cost and the difficulty in hiring employees in Singapore, restaurant C cannot further adjust its employee capacity. However, restaurant C can use some marketing strategies to smooth customer demand. For example, restaurant C can offer a discount for early birds to encourage the off-peak demand.

- Local quality. Restaurant C can reduce the number of its menu items and dedicate itself in preparing retained menu items better for customers. As mentioned in the previous solution, restaurant C can keep the food items of high order frequency, and delete the items of low order frequency. With less food variety, restaurant C can reduce the number of kitchen jobs, and can also pay more attention to the quality of customer's favorite food items.

The second root cause is that restaurant C lacks proper marketing measures to publicize itself. From the perspective of Su-Field Analysis, publics and restaurant C are two substances, S1 and S2, while their relationship represents the field F. The complete model is shown in Figure 7-14. The model represents the problem that the useful interaction between S1 and S2 is not sufficient.

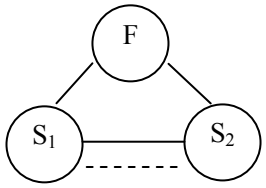


Figure 7-14: Su-Field Model of Root Cause 2 in Restaurant C

Referring to generalized solution in Appendix B, the generalized solution can be increasing the existing field (see Figure 7-15). As mentioned before, restaurant C is located in an office building where citizens and tourists seldom visit. Therefore, the specific solution of root cause 2 can be that restaurant C advertises itself through

different media channels. From the resource perspective, the environment resources of restaurant C include MRT, buses, shopping centers, and other restaurants. Therefore, to attract new customers, restaurant C can put advertisements on MRT trains and buses, and thus citizens and tourists coming to nearby area by public transportation can be attracted to restaurant C.

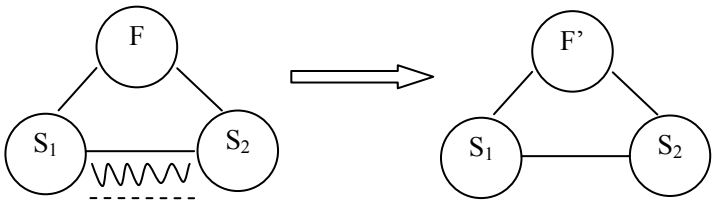


Figure 7-15: Generalized Solutions for Root Cause 2 in Restaurant C

Summary:

As a buffet style restaurant, restaurant C has encountered several UDEs due to its unique operation style and marketing strategies. The logic diagram CRT helps to understand the necessity relationships between UDEs and these root causes. The conflicts are presented in the contradictory manner by EC. The physical contradiction is solved by TRIZ 40 inventive principles and 4 separation principles. Another root causes is eliminated by using Su-Field Analysis and resource tool of TRIZ. The proposed solutions for restaurant C should be examined by the management to ascertain which one has the first priority to be implemented.

7.2.4 Case Study 4

Introduction:

Restaurant D is a fast casual dining restaurant which serves Hong Kong style food enriched by the western and Chinese dishes. The case branch is located at VivoCity

which is the largest shopping mall in Singapore. This shopping mall is directly connected to a MRT station and the tourists' attraction of Sentosa Island. Therefore, it attracts many local citizens and foreign tourists all the year round. The main customers of restaurant D are those office workers coming during the lunch time of weekdays, families in the dinner time of weekdays, and tourists and families on weekends and public holidays.

Restaurant D is a relatively medium operation with a seating capacity for 140 customers. Restaurant D mainly hires employees by posting advertisement on newspapers or restaurant front doors. It has approximately 40 employees in three departments including service, bartender, and kitchen. Among the 40 employees, nearly 15 are part-time employees who are local students without much work experience. The peak demand occurs in two time periods - lunch time from 12:30pm to 1:30pm and dinner time from 7:00pm to 9:00pm. Part-time employees help out during these two time periods. Restaurant D also provides tea time menu to customers, although it does not attract many customers as there are many alternatives such as cafes and dessert shops in VivoCity. To attract more customers, restaurant D implements tea-time promotion which offers a discount to students who come during the tea time. However, the effect is not obvious. Restaurant D operates 7 days a week, 12 to 13 hours daily according to the demand. The employees are exposed to relatively long working hours.

Process description:

The service process of restaurant D is very similar to the normal restaurants. The service process includes queuing outside for dining table, greeted and ushered in by a

waitress, placing orders, having meals, and finally making payment. As restaurant D is a fast casual dining restaurant, the management recognizes that the goal is to achieve customer satisfaction and service quality mainly through efficient service process. That is to say, restaurant D should provide customers with prompt food delivery and fast table cleaning. At the same time, management also wants to maintain the food variety and service quality as restaurant D is not a real fast food restaurant.

Problem analysis:

The observation and interview help to identify several UDEs that need to be eliminated to improve the current service process so as to achieve the goal of restaurant D.

1) The employee turnover is at a relatively high rate. When a new employee is hired, restaurant D pays him/her standard wage according to company policies. The increase in the wage for a full-time employee depends on the continuous assessment of his/her performance. Because of the long working hours and relatively rigid wage policy, new employees frequently quit their jobs. Meanwhile, many students as the part-time employees prefer to quit job when the vacation ends. Therefore, the employee turnover rate, compared to many casual dining restaurants, is at a very high rate.

2) There is a long queue during the peak demand periods. Although part-time employees help out during peak hours, there is still a long queue of customers waiting for table. As restaurant D can provide prompt service to a customer once he/she sits down, the long queue is the result of mismatch between the demand and capacity.

3) Service is responsive but not empathy enough. A customer can receive prompt service once he/she receives attention from contact employees. However, during the peak demand periods, employees are too busy to have smiles on their faces when they serve customers. Sometimes, customers cannot easily receive attention from busy employees, and they have to wave their hands many times or even place their new orders by themselves.

Rank UDEs according to the severity priority number (SPN):

During the interview, the manager estimated of degree of severity and frequency of occurrence for each UDE. The SPN for each UDE is calculated according to Equation 5-1 and shown in Table 7-10.

Table 7-10: SPN Calculation for Restaurant D

	Degree of severity	**Frequency of occurrence**	**SPN**
UDE1	3	4	12
UDE2	3	3	9
UDE3	2	3	6

CRT construction:

Built upon the identified UDEs and their causes, the corresponding CRT is built and shown in Figure 7-16 and Figure 7-17. The three-digit entity identification numbers have been arbitrarily assigned. The three main UDEs are entities whose identification number is preceded and followed by two stars (**NNN**). CRT reveals the complete effect-cause-effect relationships between three UDEs and their root causes. Two root causes are finally identified by examining the established CRT.

Root cause 1: restaurant C wants to be more profitable.

Root cause 2: most customers come during peak demand periods.

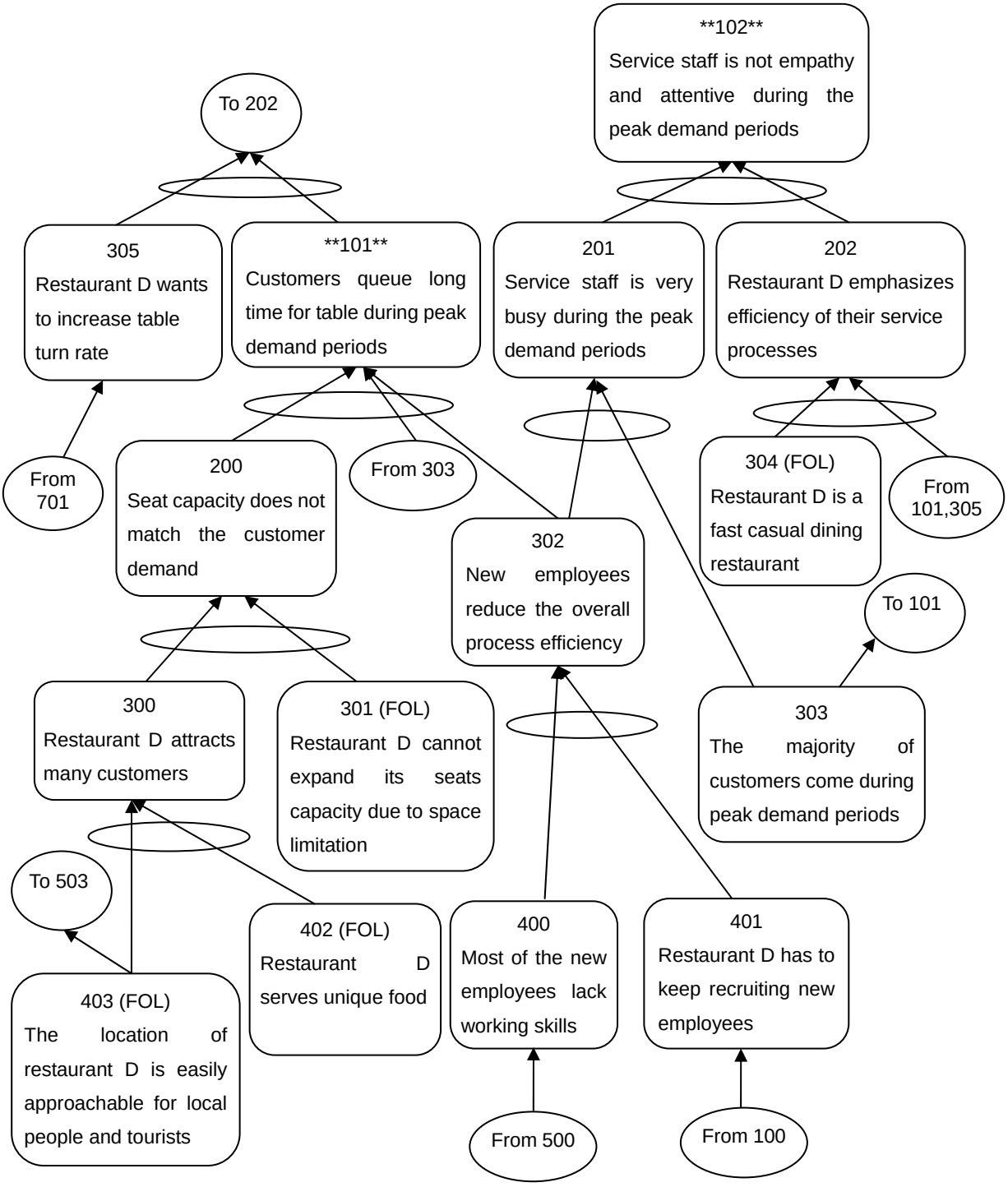


Figure 7-16: Current Reality Tree for Restaurant D – Part 1

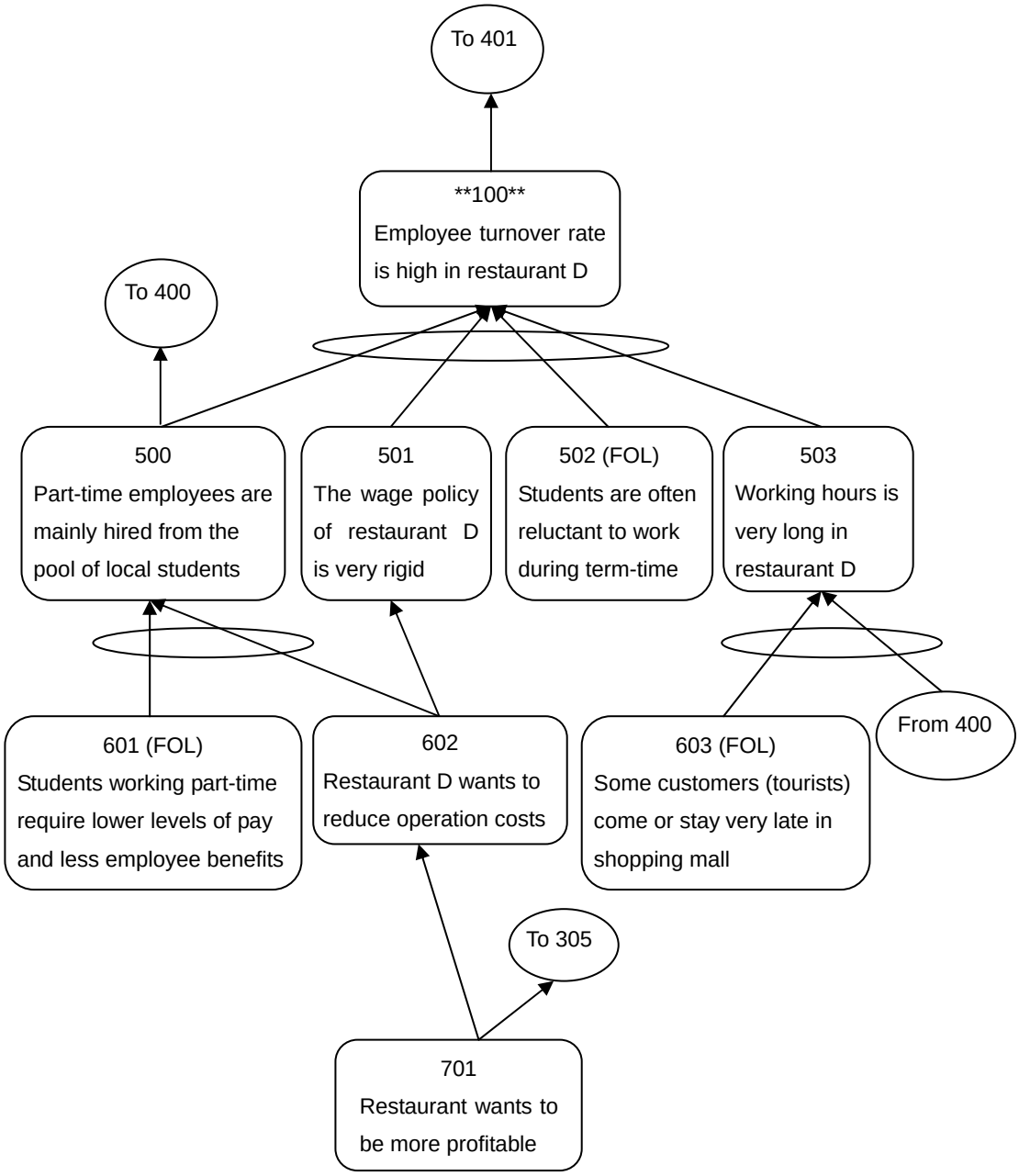


Figure 7-17: Current Reality Tree for Restaurant D – Part 2

Rank the root causes according to revised ranking method:

It can be seen from CRT, root cause 1 is associated with all the three UDEs, while root cause 2 is related to the second UDE and third UDE. Table 7-11 shows the detail of the relationships.

Table 7-11: Relationships between UDEs and Root Causes in Restaurant D

	RC1	RC2
UDE1	✓	
UDE2	✓	✓
UDE3	✓	✓

According to the revised ranking method, the relationships along with SPN for each UDE are used to calculate the weight of each root cause. The final results are shown in Table 7-12. From the results, we can see that the first root cause is the most important one that needs to be eliminated.

Table 7-12: Weight Calculation for Each Root Cause in Restaurant D

$\mathbf{W_{RC1}}$	12+9+6 = 27
$\mathbf{W_{RC2}}$	9+6 = 15

Problem resolution:

The first root cause is related to a contradiction which can be illustrated by EC. As shown in Figure 7-18, restaurant D wants to achieve the objective of being more profitable by fulfilling two necessary requirements. On one hand, restaurant D should reduce operation cost by hiring local students as part-time employees, as they often require less salary and welfare. On the other hand, restaurant D should increase the efficiency of their service process. The prerequisite of this requirement is that restaurant D should have senior employees with work experience and proper service skills.

To solve this contradiction, we may first consider the technical contradictions represented by two requirements: operation cost and process efficiency. However, as "cost" is not a generic parameter in the contradiction matrix, we cannot directly use it

to find the corresponding inventive principles. According to Domb (2006), some alternative items can be used to describe cost-related problems:

- Speed of a process
- Duration of action
- Loss of energy, loss of substance, loss of information, loss of time
- Reliability
- System-generated harmful factors
- Ease of operation, ease of production, ease of repair
- System complexity
- Extent of automation
- Productivity

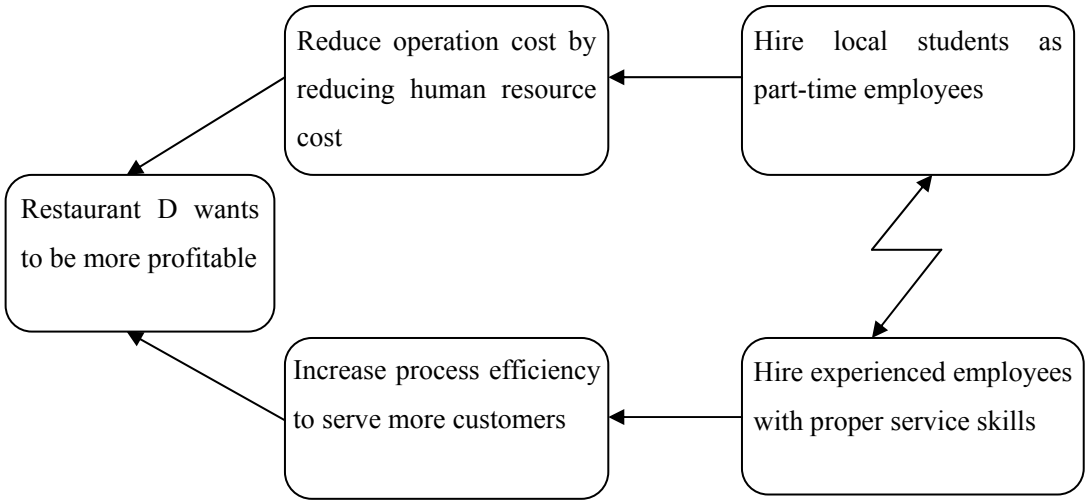


Figure 7-18: Evaporation Cloud for Restaurant D

Referring to Appendix A, we can consider cost reduction as the parameter of "loss of substance" and process efficiency as the parameter of "speed". From the contradiction matrix, the suggested inventive principles are 10-preliminary action, 13-the other way

around, 28-mechanical substitution, and 38-strong oxidants. By examining these principles, two possible solutions are derived.

- Preliminary action. Some part-time employees can be hired as the back-up employees. When some employees quit their job, these employees can quickly fill the vacancies. Meanwhile, restaurant D can interview more candidates than they need in their recruitment activities, and keep the information of all qualified candidates. The qualified but unhired candidates can be viewed as potential employees who can be used to fill the vacancies when current employees quit.
- The other way round. Instead of taking food to customers, restaurant D can let customers order and pick their food by themselves. In this way, fewer employees are required to serve customers, and current employees are less busy in serving food to customers. As the service become self-service, employee attentiveness is no longer a problem.
- Mechanics substitution. Restaurant D can use electronic mobile device to interact with customers. For example, restaurant D assigns a mobile device to a customer when he/she places an order. When food is ready, the employee in charge can notify a waitress/waiter to take food to the corresponding table, or inform a customer through the mobile device to take food by himself/herself if restaurant D decides to operate in the self-service style. Moreover, the customer, if possible, can inform restaurant D when they need some additional services through the mobile device. This kind of service is very similar to ring for service in the flight travelling.

The second root cause that the majority of customers come during peak demand periods can be formulated by Su-Field Analysis. Customers and restaurant D are two substances, S1 and S2, while their relationship represents the field F. The complete model is shown in Figure 7-19. The model represents the problem that the useful interaction between S1 and S2 is excessive due to the rhythm match in the system.

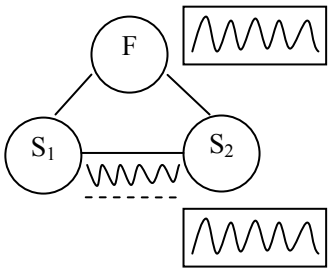


Figure 7-19: Su-Field Model of Root Cause 2 in Restaurant D

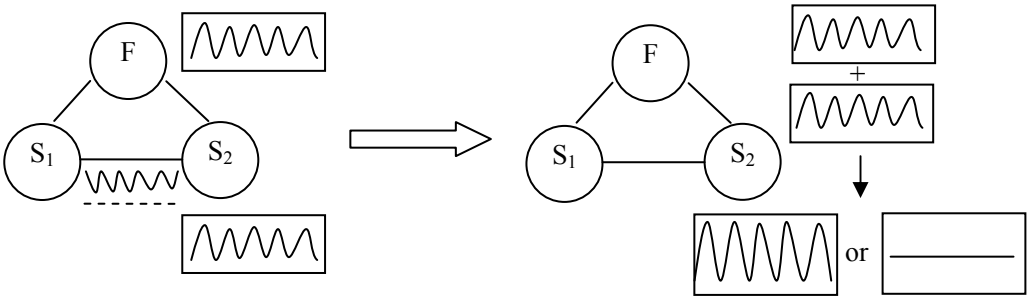


Figure 7-20: Generalized Solution for Root Cause 2 in Restaurant D

Referring to the generalized solutions in Appendix B, the abstract solution can be mismatching the frequency of field with existing substances (see Figure 7-20). Specifically, restaurant D can adopt some marketing strategies to change customer behaviors or smooth customer demands. For example, restaurant D can offer some discounts to customers coming beyond peak hours. In addition, restaurant D can offer customers coupons which entitle them to have a certain discount or other privileges for the tea time menu. In this way, restaurant D can not only alleviate work load during the two peak demand periods, but also increase the profit from the tea time operations.

Summary:

Built upon three UDEs, the logic diagram CRT helps to understand the effect-cause-effect relationships and drill down to two root causes in a fast casual dining restaurant. The first root cause is related to a contradiction which is presented by EC. The identified technical contradiction is solved by TRIZ contradiction matrix and corresponding inventive principles. The second root cause is formulated and eliminated by using Su-Field Analysis. The proposed solutions for restaurant D should be examined by management to ascertain which one has the first priority to be implemented based on their consideration of financial condition, time, and human resources.

7.2.5 Case Study 5

Introduction:

As a Chinese casual dining restaurant, restaurant E is located at a new shopping center and mainly serves soup noodles and Chinese dishes. The major customers are those Chinese people who come from China and are now studying, living, or working in Singapore. As it is very near National University of Singapore (NUS), most of its customers are those Chinese students in NUS. Meanwhile, restaurant E also attracts some local Chinese Singaporeans which are the second biggest customer segment.

Restaurant E moved in a relatively new shopping mall opened in year 2008. Restaurant E is a relatively medium operation with maximal seating capacity of 80 customers. Restaurant E mainly hires employees from the local job market by posting advertisement on newspapers and hires foreign workers from China through

commercial recruitment agencies. It now has 15 full-time employees including managers, waiters, and kitchen staff.

Process description:

The service process of restaurant E is very similar to normal restaurants. The service process includes queuing outside for dining table, greeted and ushered in by a waitress, placing orders, having meals, and finally making payment. The goals of restaurant E are to maintain the service quality and enhance profitability.

Problem analysis:

The direct observation and interview help to identify two main UDEs that need to be eliminated to improve the current service process so as to maintain service quality and increase the profit margin.

1) Profitability of current service process is very low. The manager indicated that the current profit margin in the restaurant E is very low, and sometimes there is even no profit for some weeks, and the revenue can only maintain its daily operations. One important reason is that the restaurant lacks marketing capability to attract new customers as well as to retain the current customers. Although restaurant D knows exactly about who are its major customers, it has no corresponding marketing strategies to attract those new customers. The manager indicated that restaurant D mainly attracts new customers by word-of-mouth effects among students in NUS. Meanwhile, some off-campus living students who live in nearby area may also become its customers. However, these two sources of customers cannot generate substantial income. Those students are not stable customers as most of them will leave NUS after

they graduate. The word-of-mouth effect is not very effective for the population with relatively high flow rate.

2) Inconsistence in food quality. This UDE results from the different eating habits between Chinese people from China and local Chinese Singaporeans. To attract and retain the major customer segment, restaurant E wants to maintain the original tastes of their food items. However, these kinds of food items are usually too salty and oily for Singaporeans. Therefore, to cater for local Chinese people, restaurant E has to localize their food to some extent, which finally results in the fact that some frequently visited customers have perceived the inconsistence of the food quality. As the first segment of customers prefer the original taste, the inconsistent food quality usually generates negative word-of-mouth and finally causes the loss of current and potential customers.

Rank UDEs according to the severity priority number (SPN):

During the interview, manager gave the estimates of degree of severity and frequency of occurrence for each UDE. The severity priority number (SPN) for each UDE is calculated according to Equation 5-1 and shown in Table 7-13.

Table 7-13: SPN Calculation for Restaurant E

	Degree of severity	**Frequency of occurrence**	**SPN**
UDE1	4	3	12
UDE2	2	2	4

CRT construction:

From the identified UDEs and their causes, the corresponding CRT is built and shown in Figure 7-21. The three-digit entity identification numbers have been arbitrarily

assigned. The three main UDEs are entities whose identification numbers are preceded and followed by two stars (**NNN**). CRT reveals the complete effect-cause-effect relationships between two UDEs and their root causes. Two root causes are finally identified by examining the established CRT.

Root cause 1: restaurant E attracts their new customers only by the word-of-mouth effects.

Root cause 2: the original tastes of food are too salty and oily for the local people.

Rank the root causes according to revised ranking method:

It can be seen from CRT, root cause 1 is associated with the first UDE, while root cause 2 is related to both the first UDE and the second UDE. Table 7-14 shows the detail of the relationships.

Table 7-14: Relationships between UDEs and Root Causes in Restaurant E

	RC1	**RC2**
UDE1	✓	✓
UDE2		✓

According to the revised ranking method, the relationships and SPN of each UDE are used to calculate the weight of each root cause. The final results are shown in Table 7-15. From the results, we can see that the second root cause is the most important one that needs to be eliminated.

Table 7-15: Weight Calculation for Each Root Cause in Restaurant E

$\mathbf{W_{RC1}}$	12
$\mathbf{W_{RC2}}$	12+4 = 16

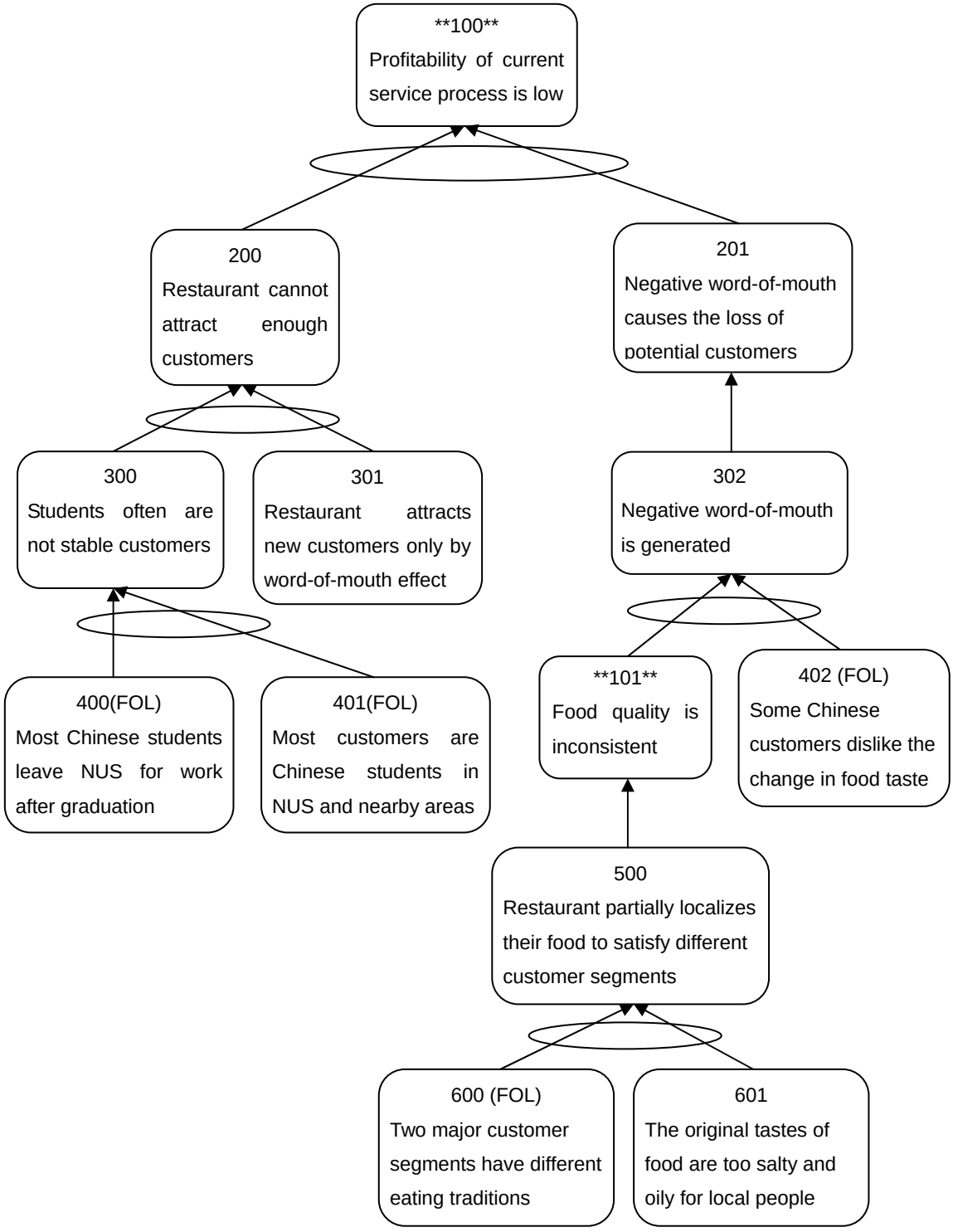


Figure 7-21: Current Reality Tree for Restaurant E

Problem resolution:

The root cause 2 can be represented in a contradictory manner by EC (see Figure 7-22).

On one hand, restaurant wants to retain the first segment of customers by keeping

original tastes of their food items. On the other hand, restaurant has to localize their food to accommodate the requirements from the second customer segment.

To make the contradiction more clearly, we can re-write it into two extremes: “localize the tastes of food items” versus “do not localize the tastes of food items”. To solve this physical contradiction, we can use 4 separation principles and 40 inventive principles.

- Separation upon conditions. Restaurant E can adjust the tastes of food items for customers in different segments. Normally, when a Chinese customer comes, restaurant can serve food in its original taste. On the contrary, when a local Singaporean comes, the waitress should inform kitchen staff to make necessary adjustments to the food preparation. Effectiveness of this solution largely depends on the ability of waitress to distinguish different customers and the ability of kitchen staff to flexibly prepare food in different tastes. Usually, Chinese customers from China and local Singaporeans have different accents which can be a measure to differentiate them. Meanwhile, restaurant E can establish two standardized procedures for preparing two kinds of food. This solution can also be recognized as the principle of segmentation.

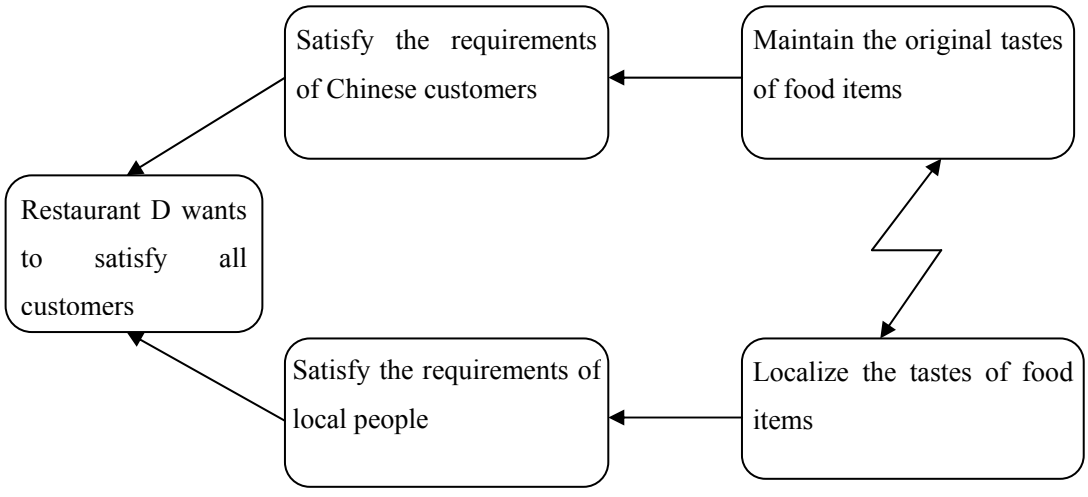


Figure 7-22: Evaporation Cloud for Restaurant E

The root cause 1, restaurant E attracts new customers only by word-of-mouth effects, can be formulated by Su-Field Analysis. Customers and restaurant E are two substances, S1 and S2, while their relationship represents the field F. The complete model is shown in Figure 7-23. The model represents the problem that the useful interaction between S1 and S2 is insufficient.

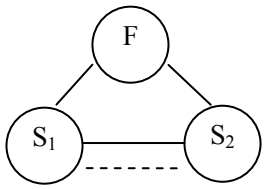


Figure 7-23: Su-Field Model of Root Cause 1 in Restaurant E

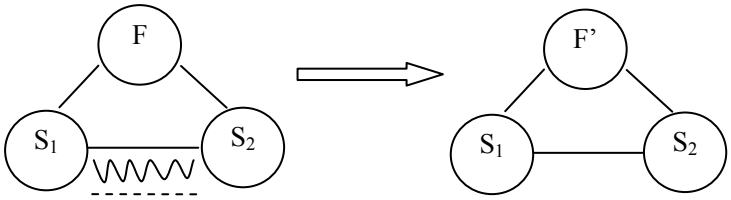


Figure 7-24: Generalized Solution for Root Cause 1 in Restaurant E

Referring to the generalized solutions in Appendix B, the abstract solution can be increasing the existing field (see Figure 7-24). Although restaurant E already knows that major customers are those Chinese students in NUS, it does not establish enough connections with its customers. Therefore, restaurant E should enhance its relationship with its major customers. Specifically, restaurant E can establish the connection with the student union or graduate student society, and it may sponsor some student activities such as new student welcome activity in NUS to sell its brand name to more Chinese students. It is also beneficial if restaurant E posts advertisement on the online forums, such as www.huasing.org, bbs.sgchinese.com, etc., which are visited by most

of Chinese students. In summary, restaurant E should establish different channels through which its major customers can learn about restaurant E.

Summary:

Built upon several UDEs, the logic diagram CRT helps to understand the necessity relationships underlying the conflicts and root causes associated with various UDEs. The conflict is presented in a contradictory manner by EC, which is solved by TRIZ 4 separation principles. Another root cause is eliminated by using Su-Field Analysis. The proposed solutions for restaurant E should be examined by management to decide which one has the first priority to be implemented based on their consideration of organization resources.

7.3 Implications

The application of TOC has been somewhat limited in service sectors because of two reasons. First, it was originally developed and successfully implemented in the manufacturing industry. Therefore, most people think it is tightly linked to manufacturing. Second, services have some unique characteristics such as intangibility, inability to be inventoried, and simultaneous production and consumption. These characteristics seem to impose challenges to adopt TOC in services. Fortunately, the advent of TOC TP broadens its application in policy constraints and ill-structured problems in every aspect of businesses. TOC TP helps to find the true policy constraint instead of the obvious physical constraint in a service organization. For example, the service manager in restaurant C found that the customer's waiting time for food is very long. The traditional managerial viewpoints may regard the staffing level in the kitchen as the physical constraint which finally results in the long waiting time. However,

increasing the number of kitchen employees may not fundamentally reduce customer's waiting time for food, but it will increase the human resource cost. Through rigorous analysis, TOC TP helped to identify the true policy constraint – food is prepared in the way of "making to order", which was then expressed as a contradiction and solved by TRIZ contradiction elimination tools. By using TOC TP, service manager can strategically locate this fundamental constraint for global performance improvement.

TRIZ, invented in the technical field, has been proven to be effective in generating ideas and solving problems in various non-technical areas. For the identified problems, TRIZ is powerful in modeling the abstract problems and generating a considerable amount of abstract solutions. For service process improvement, it is necessary to retain enough preliminary ideas at the early stage. The powerful knowledge base and various tools of TRIZ enable it to generate enough number of innovative ideas. The contradiction elimination tools of TRIZ are still the most powerful and widely used tools which can be utilized to generate solutions to core conflicts. The Su-Field Analysis is straightforward and effective to model a mini-problem which only involves a small number of elements. Finally, service managers can evaluate the generated solutions based on their consideration of expected benefits and financial conditions, time, and human resources costs incurred.

The proposed framework provides service managers with a systematical approach which considers the problematic process and related elements as a whole to find the correct root causes to improve their service process. The step-by-step instructions described in this framework enables service managers to conduct a rigorous and complete process improvement program starting from problem definition to final

solution generation. When implementing this framework, service managers should also pay attention to a few points. First, a service manager should collect different viewpoints about the existing problems from pertinent people such as customers, waitress, kitchen staff, and other managers. Synthesizing data from different sources can help to avoid bias and identify uncovered problems, thus producing a more comprehensive logic diagram.

Second, the construction process of CRT diagram requires much attention to details and several iterations of tree construction, and thus it takes time and effort for users to complete an acceptable CRT diagram. As shown in case studies, the root causes as the policy constraints may not only appear within a service process, but also can emerge in other support processes such as service recovery, employee recruitment, and marketing activities. Therefore, CRT construction encourages communication across departments within an organization to analyze the problem in a more systematic way, and a comprehensive CRT diagram is more probably to identify the true root cause as policy constraint. In addition, to ensure the validity of logic relationships, service managers should use the categories of legitimate reservation (CLR) as proof-reading tools to examine the logical cause and effect relationships. Meanwhile, service managers should also carefully refine the words and phrases contained within entities of CRT. Therefore, service managers should pay enough attention to CRT construction for problem identification rather than hastens to proceed to the next step for solution generation.

Third, as TRIZ is somewhat complicated for beginners, service managers who intend to adopt this framework and encourage innovation within their organizations may

consider introducing and using TRIZ tools such as 40 inventive principles, contradiction matrix, and Su-Field Analysis in the beginning. As these TRIZ tools have already adapted for services and used in this thesis, new users may have less difficulty in implementing them in the service context. Other TRIZ tools such as resources, effects, evolution pattern, trimming, and ARIZ can be gradually introduced into their organizations if necessary.

The proposed framework provides a qualitative approach to service process improvement. As service processes are largely people-driven, measurements are often non-existent or ill-defined, and data collection is one of the most serious problems faced by service organizations which intend to implement data-driven approaches like Six Sigma. For example, a data-driven approach can help a restaurant to model the actual table turn rate based on the number of existing tables and the arrival and leave rate of customers in a certain period, but it is difficult for the data-driven approach to deal with the relationship between customer's complaint behaviors and seating types in a numerical way. The qualitative approach has inherent strength in building logical relationships among various causes and effects, and it can logically handle the people-driven and ill-structured problems in a service process. As shown in the case study of restaurant B, the table turn rate was found to be related to the location of restaurant B and restaurant's policy of allocating different types of seats to customers, and it finally resulted in the UDE of customer's long waiting time for the dining table. However, it is unreasonable to arrive at a conclusion that the qualitative approach is better than the data-driven approach. Service managers should note that the qualitative approach and data-driven approach can complement each other. They have their own

merits in service process improvement. Service managers can combine these two types of approaches to reap more benefits in their service process improvement.

As the proposed framework is capable of being implemented without significant investment, extensive training, and involvement of entire workforce, it is a good choice for SMEs which lack monetary and non-monetary resources to implement service process improvement programs. As shown in case studies, all the five case restaurants belong to SMEs which are often confronted with leadership deficiencies, inadequate funding, and lack of human resource, time, and knowledge. Therefore, they are reluctant to implement any service process improvement program, even though they are aware of the necessity. By utilizing the proposed framework, service managers may find that a small team with approximate 2-3 team members can complete an improvement project. As the common principle of TOC TP and TRIZ is to achieve the most possible benefits with minimum introduction of new resources and cost, the proposed framework can easily incorporate those resource limitations into CRT construction and solution generation. Therefore, SME service companies can now afford to improve their service processes with less initial investment.

Chapter 8 Discussion and Conclusion

In this final chapter, a brief summary of this thesis is presented. The contributions of this thesis to service process improvement and TRIZ and TOC methodologies are presented. Limitations of this research thesis will also be discussed. Finally, recommendations for further studies and research are presented.

8.1 Contributions

In this thesis, we proposed a formalized framework which uses a qualitative approach to improve service processes. This study firstly integrated two manufacturing originated tools of TOC TP and TRIZ for services, aiming at providing a systematic and innovative process improvement approach to service companies, especially those SME service companies.

From the various literature reviewed, this thesis found that practitioners lack systematic and innovative tools to improve service processes. Most of the process-oriented tools can only address parts of a service process rather than picture a system view. Meanwhile, lack of innovation capability also somewhat limits their possibility of bringing competitive advantages to service companies. Although the established methodologies like six-sigma and lean are of formulized mechanisms, they require the significant initial investment and extensive commitment which are often unaffordable for many SMEs in the service industry.

Therefore, a formalized framework has been proposed to address the needs of SMEs to improve their service processes, and the case studies demonstrated that our proposed

framework can meet the tool requirements of SMEs. Firstly, our results suggested that service process improvement should have a systematic view and dedicate to finding the true policy constraints as the root causes of service process problems. By including TOC TP tools in the framework, practitioners can take a systematic view of service processes and existing problems without extensive data collection and personnel training. SMEs do not need to invest too much on staff training or involve all employees in their improvement programs. Managers can easily locate the most important root causes as policy constraints, and generate solutions with minimum introduction of new resources. Meanwhile, the revised ranking method developed in this thesis considered both the qualitative effect-cause-effect relationships and the quantitative information of problems, so managers can have a more clear judgment about which policy constraint is more urgent for them to develop corresponding actions. Therefore, service managers as practitioners with limited time and energy are able to pay attention to those leverage points that will create a significant impact on the global performance. All these features help SMEs to reduce improvement cost. Secondly, as TRIZ is embedded in our proposed framework, SMEs can utilize the powerful knowledge base of TRIZ when they generate solutions. TRIZ is a channel for SMEs to bring external expertise and innovation into their organizations. With the help of TRIZ tools, they can now generate creative and innovative improvement ideas and solutions to gain competitive advantages. Moreover, with the development of TRIZ in services, SMEs in the service industry can benefit more from our proposed framework. Thirdly, the proposed framework provided SMEs with a systematic way to improve their service processes. The instructions and detailed procedures of this framework enable practitioners to straightforwardly implement this framework for their process improvement and innovation. Therefore, the proposed framework can meet the special

tool requirements of SMEs in the service industry and help them effectively improve their service processes.

The systematical approach provided step-by-step instructions which can be easily comprehended and implemented by practitioners. TOC TP has been developed and widely implemented in the manufacturing context, and TRIZ has been invented and applied in technical fields. Therefore, practitioners from the service industry are highly likely to be unfamiliar with those two methodologies. However, the step-by-step instructions associated with the proposed framework clearly stated the tasks and procedures in each step. Following the instruction and detailed procedures, practitioners can find that it is very straightforward to implement this framework.

From TOC and TRIZ perspective, this study also contributed to studies and application of these two methodologies. Firstly, the five case studies widen the studies of TOC and TRIZ beyond the manufacturing industry and confirmed their usability in wide ranges of problems. The literature review showed that the application of TOC and TRIZ mainly focused on the problems in the manufacturing industry and technical fields, although they are supposed to be universally applicable for any situation. For services, there are still very limited studies regarding TOC and TRIZ applications, despite the fact that service scholars increasingly pay attention to these two methodologies. To fill this gap, this thesis built five case studies in the service context. The five case studies in this thesis further justified the applicability of TOC and TRIZ in the service context, and would hopefully propel the studies and application of them in more broad areas.

Secondly, adaption of TRIZ tools in services enriched the theoretical studies of TRIZ in services and facilitates the application of TRIZ in services. A strength of TRIZ is that it has many practical tools, but it is also confusing for most beginners to learn and choose right tools for their problems. Moreover, most TRIZ tools have obvious technical features which prevent practitioners from comprehending these tools and slow down the spread of TRIZ tools over non-technical areas. This study provided the adapted version of some TRIZ tools including 39 generic parameters and Su-Field Analysis in the service context. New TRIZ users from the service industry can firstly use the adapted version of these TRIZ tools when they start applying TRIZ to service problems. The adapted version of TRIZ tools can help them to shorten their learning cycle and accelerate the process from learning to practicing. With the knowledge and experience gained from using these adapted TRIZ tools, practitioners can gradually try to utilize other TRIZ tools for service problems.

Thirdly, the new way of integrating TP and TRIZ overcome the limitations of the traditional integration and extends the utilization of various TRIZ tools. Traditional way of integration of TOC TP and TRIZ for problem solving adopts the CRT-EC-TRIZ process which emphasizes the contradiction elimination. Although the CRT-EC-TRIZ method is effective in finding the critical problems, it suffers from losing opportunities to generate enough good ideas. Meanwhile, TRIZ is much more than contradiction elimination. The new way of integrating TP and TRIZ is able to utilize more TRIZ tools and helps users to generate more innovative solutions for further evaluation. In our case studies, different TRIZ tools including 40 inventive principles, 4 separation principles, contradiction matrix, resource, and Su-Filed Analysis were used for solution generation. The use of different TRIZ tools can

produce more opportunities to generate a sufficient number of useful ideas for further evaluation.

With the empirical verification of the proposed framework through the five case studies presented in this thesis, service firms and organizations, not necessarily from the restaurant sector, can utilize the derived findings from case studies to help them improve their current service processes. The five case studies have discussed various service process problems or UDEs that result from the root causes in service recovery, process design, tangibles, employee recruitment, and marketing activities in restaurants. Through understanding the relationships between process problems and areas where root causes resident, service companies may find similar process improvement opportunities as discussed in our case studies.

Finally, practitioners, not necessarily from the field of service process improvement, can gain more insights from this thesis to help them in various improvement practices. They may consider applying the proposed framework for other aspects of their businesses and management activities, as the framework does not adhere to a specific service sector or a specific kind of service process. Moreover, they can also combine this framework with existing improvement practices in their organization to reap more benefits for their organizations.

8.2 Limitations

Due to the time and resource limits, this study only investigated the Chinese casual dining restaurants in Singapore. Other common service sectors were not studied in this research project. As the typical problems usually differ among various service sectors,

the solutions and findings derived from the case studies may be unsuitable for other service sectors. Practitioners from other service sectors should not adhere to the findings of the case studies in this thesis, but they should apply the framework to their unique problems.

The nature of this study requires in-depth investigations, thus the number of case studies is restricted. This thesis only has five case studies. Meanwhile, as interviewees were often very cautious or even defensive when they answered some problem-related questions during the interview process, some interview sessions were proven unsuccessful and have been discard during the thesis writing. Therefore, the thesis only analyzed 5 case studies which may not be sufficient to cover all common problems in the restaurant industry in Singapore. Meanwhile, because of the exploratory purpose of this study and the limitation of time, this thesis did not consider the solution evaluation in the proposed framework. Therefore, the generated solutions were not examined by the managers in the case restaurants.

8.3 Further Research

Through the findings of this research project, the effectiveness of proposed framework for service process improvement has been demonstrated. The proposed framework can be used as a formalized procedure for practitioners involved in service process improvement. However, as mentioned previously, this research has its own limitations. Further research may dedicate to overcoming these limitations.

Firstly, future research may focus on the more wide empirical validation of this framework. The proposed framework can be applied to other important service sectors.

Some process-based service classification schemes (E.g. Schmenner 1986; Silvestro et al. 1992) are useful in selecting service sectors with different process characteristics.

Secondly, this framework did not cover the solution evaluation and implementation. Future research may expand the framework and develop the procedures to evaluate the generated solutions. So, the solutions could be examined by users in the real world and ideally be tried in the case companies.

Thirdly, some ideas from the data-driven methods like Six Sigma can be utilized to enhance the proposed framework. For example, Ehie and Sheu (2005) proposed an integrated TOC/Six Sigma framework which combined their respective strengths of global improvement and data-driven analysis for a manufacturing company. It is also worth to exploring this idea in the service context.

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Appendix A 39 Generic Parameters in Services

1 and 2 — Weight of moving/binding object: The mass of the object, in a gravitational field. The force that the body exerts on its support or suspension, or on the surface on which it rests.

- The importance or benefits of a service delivery activity to the customer (perceived) value. Some activities play a critical role in the service delivery process (e.g. cocking food for a customer in the restaurant), while other activities have relatively less influence on customer satisfaction (e.g. greeting customers upon arrival).
- The importance or benefits of a service feature to customer (perceived) value.

3 and 4 — Length of moving/binding object: A geometric characteristic described by the part of a line (straight or curved and not necessarily the longest) that can be measured by any unit of linear dimension, such as meter, inch, etc.

5 and 6 — Area of moving/binding object: A geometric characteristic described by the part of a plane enclosed by a finite continuous line that can be measured in a square unit of dimension. The part of a surface occupied by the subsystem.

7 and 8 — Volume of moving/binding object: A geometric characteristic described by the part of a space that can be measured in a cubic unit of dimension. The part of a space, either internal or external, occupied by the subsystem.

3-8 — Geometric size of moving/binding object:

- Geometric size of service facilities, equipment, tangible products.

9 — Speed: The velocity of the subsystem. The rate of a process or action in time that can be measured by any linear unit of length divided by a time unit.

- The velocity of a service employee or equipment to perform an activity during a service delivery process. Time efficiency of service employees.
- Responsiveness also reflects the speed of service employees.

10 — Force: Any interaction that can change the subsystem's condition due to the interaction between subsystems.

- Any interaction between customers and service employees or within employees.

11 — Stress or pressure: Tension on or inside the subsystem

- Job stress or pressure of service employees. It is often caused by high level of work load, role conflict and ambiguity, special customer requirements, etc.

12 — Shape: The external contours, boundaries, that separate the subsystem from the environment or other subsystems. The appearance of the subsystem in the space.

- Boundaries of service offerings. Different customers may receive bundled service offerings with different features or functions.

- Appearance of tangible elements in service offerings (e.g. for online services, it refers to the appearance of website).
- Physical shape of service equipment and facilities; layout design of workplace.

13 — Stability of the subsystems: The ability of the subsystem to keep its integrity (wholeness). Steadiness of the subsystem's elements in time. Wear, chemical decomposition, disassembly, and growth of entropy are all decrease in stability.

- Steadiness of elements in service delivery systems. Staff turnover, wear of service facilities and equipment, and customer loss are all decrease in stability.
- Consistence of individual service offering in a long time.

14 — Strength: The ability of the subsystem to resist a change in response to force. Resistance to breaking.

- Customer loyalty and retention. Customer's willingness of continuing the relationship with a service firm. Loyal customers would not easily switch service providers despite of some unsuccessful interactions with the service firm.
- Employee loyalty or organizational commitment. Employee's willingness of keeping stay at the job position.

15 and 16 — Duration of moving/binding object: The time during which the subsystem can perform useful and/or neutral function (durability). It can be estimated as the average period between failures, the service life.

- As service is perishable, the durability can only make sense in terms of elements in service systems, especially the service facilities. Durability is the duration for which the service systems have been continuously operated without failure. (e.g. online retailing service is designed to be provided 24 hours per day, 365 days per year, but it may be breakdown due to the server fails or attack by hackers).
- Unlike service itself, service benefits can last for a period of time. Durability can also be the duration of the benefits, or the amount of time the consumer expects the benefits of the service to last.

17 — Temperature: The thermal condition of the subsystem. Liberally includes other thermal parameters, such as heat capacity, that affect the rate of temperature change.

- Temperature of service products such as food.
- Temperature of physical facilities or environment

18 — Brightness: Light flux per unit area. Also any other illumination characteristics of the subsystem, such as light intensity, degree of illumination.

- Visibility: The extent to which a customer is allowed to see all of or only a portion of the service production and delivery process, i.e. the transparency of a service delivery process to a customer. (e.g. some restaurants make their food preparation activities visible to customers, thus increasing the customer perception of hygiene and efficiency)
- Degree of illumination in the service workplace.

19 and 20 — Energy spent by moving/binding object: The subsystem's requirement (such as electricity or rotation) to perform a particular function. Often energy is

provided by the technique or super-system.

- Employee effort is the amount of energy expended by an employee on behalf of a customer during a service delivery process.
- Energy usage (such as electricity) of various equipments for operating the service process.

21 — Power: The time rate of energy usage due to which the subsystem's functions are performed.

- Amount of work a service employee or equipment does in a period of time.
- Efficiency of a service employee (similar to 9-speed).

22 — Loss of energy: Use of energy (such as heat) that does not contribute to the job being done (compare with 19 and 20). Reducing energy loss sometimes requires heuristics that are different from the heuristics for improving energy usage. Consequently, energy waste is a separate parameter.

- Extra effort or energy which does not contribute to the value of customer and profits of service firm.

23 — Loss of substance: Partial or complete, permanent or temporary loss of some of the subsystem's materials or elements.

- Partial or complete, permanent or temporary idleness of work force, equipment, or facilities.
- Waste of service functions contained in or costs associated with service offerings.

24 — Loss of information: Partial or complete, permanent or temporary loss of data or access to data in or by the subsystem. Frequently includes sensory data such as aroma, texture, etc.

- Partial or complete, permanent or temporary loss of information or access to information in the service process. Most of the information comes from communications between (external and internal) customers and service providers, such as the customer's wishes, special needs, deadlines, preferred suppliers and materials, etc. (e.g. only 5 to 10 percent of dissatisfied customers choose to complain following a service failure, as the consequence, the service firms lose much precious information to recovery from the service failures or service (process) improvement).

25 — Waste of time: Time is the duration of an activity. Improving the loss of time means reducing the time taken out of the activity. "Cycle time reduction" is a common term.

- Time is the duration of an activity. In a service process, the time dimension may covers task time, total process time, customer contact time, waiting time and throughput time. Improving the loss of time means reducing the time taken out of the activity or the whole service process. "Cycle time reduction" is a common term.

26 — Amount of substances: The number of the subsystem's materials or elements that might be changed fully or partially, permanently or temporarily.

- The number of work force, equipment and facilities and associated costs required for delivering service (e.g. a service firm may temporarily increase the number of employees during the peak hours; extra cost is required for training customers for using new delivery system).
- Completeness of a service offering for a customer or the corresponding customer segment.

27 — Reliability: The subsystem's ability to perform its intended functions in predictable way and conditions.

- The service provider's ability to perform the promised service dependably and accurately the first time. Low reliability is often the cause of service failures during the service delivery process.

28 — Accuracy of measurement: The closeness of the measured value to the actual value of the subsystem parameter.

- The closeness of the assessed customer requirement (or symptom) to the actual customer requirement (or symptom) (e.g. Accuracy of a doctor in diagnosing and judging the patient's condition; accuracy of evaluating the severity of car breakdown problems in repairing service).

29 — Accuracy of manufacturing: The closeness of the actual characteristics of the subsystem to the specified or required characteristics that can be achieved during the subsystem production. (Note that manufacturing precision is often connected with the quality of the subsystem.)

- The closeness of the actual delivery of the service to the specification for the service, i.e. service performance gap.
- The closeness of the actual delivery of the service to the customer expectation for the service.

30 — Harmful factors acting on subsystem: Susceptibility of the subsystem to externally generated harmful effects.

- Harmful effects generated by external environment such as market factors, social factors, ecological factors, legal factors, etc. (e.g. Negative word of mouth effects may spoil customer's the perception of service quality; abominable weather may seriously influence the transportation services; weak legal protection for service results in easy copying by competitors)

31 — Harmful side effects: A harmful effect that is generated by the subsystem as part of its operation within the technique, and that reduces the efficiency or quality of the functioning of the subsystem or whole technique.

- A harmful side effect that is generated by an activity as part of its operation within the service process, and that reduces the efficiency or quality of the service process. Harmful side effects may physically occur or be perceived by customers (e.g. customer participation is unavoidable in most of service processes, but it may decrease the reliability of the service process for the introduced uncertainty).

32 — Ease of manufacture: The degree of facility, comfort, ease, or effortlessness in manufacturing or fabricating of the subsystem.

- Ease of service delivery. Service delivery process requires less personnel skills, knowledge, resources and unnecessary service variability. Since service production and consumption often occurs simultaneously, ease of manufacture and ease of use (see 33-ease of use) have some overlaps.
- Accessibility: A customer's ability to avail him/herself of the services at the instance of the service encounter (Mayer et al. 2003).As customers cannot absent from the service production (manufacture), high accessibility implies ease to produce and delivery.
- "Design-for-implementation" for service development is an analogue to "design-for-manufacturing for product development.

33 — Ease of use: simplicity and ease of operation. The technique is not convenient if it requires many steps to operate or needs special tools, many highly skilled workers, etc. Often a convenient process has high yield due to the possibility to do it right.

- Simplicity and ease of operation. The procedure to execute a task is concise, orderly, and easy-to-understand. Employees and customers without much special knowledge or training could easily operate the service equipment or work together to complete a service activity (e.g. self-service is often set up to cope with mass service requirement, and the procedures are usually simple and easy to be understood, and customers without special training can fully operate).
- The technology is readiness to use. User-friendliness of service equipments.

34 — Repairability: Quality characteristics such as convenience, comfort, simplicity, and time to repair faults, failures, or defects in the subsystem.

- Recoverability: Ability of service firms to restore customer satisfaction or even exceed their expectation (recovery paradox), from a service failure or a crisis. (e.g. service firms empower their front-line employees to proactively deal with service failures during the service process may increase the probability of successful recovery). Completeness and effectiveness of recovery policy and procedures also reflect the recoverability.

35 — Adaptability: The ability of the subsystem to respond positively to external changes, and the versatility of the subsystem that can be used in multiple ways under a variety of circumstances.

- The ability of a service process in providing multiple services to meet changing and/or customized demands. It is often achieved by flexible capability allocation or adaptive behaviors of front-line contact employees.
- Degree of Customization: service providers adjust the system to accommodate customer requirements, and provide unique service offerings to different customer segments or even individual customers.

36 — Device and system complexity: The number and diversity of elements and element interrelationships within the subsystem. The user may be an element of the subsystem that increases the complexity. The difficulty of mastering the subsystem is a measure of its complexity.

- The number and diversity of the steps or activities and the interrelationships between the steps within a service process. Customer participation often increases the complexity.

37 — Difficulty of detecting and measuring: Measuring or monitoring the subsystems that are complex, costly, and require much time and labor to set up and use, or that have fuzzy relationships between components or components that interfere with each other all demonstrate "difficult to detect and measure." Increasing cost of measuring to a satisfactory error is also a sign of increased difficulty of measuring.

- Measuring and monitoring a service delivery process is difficult, costly, and time-consuming. Intangibility of service and degree of labor intensity can be possible indicator of difficulty of measuring. Location dispersion in services also increases the difficulty of monitoring, such as real time tracking in global logistic services.

38 — Level of automation: The ability of the subsystem to perform its functions without human interface. The lowest level of automation is the use of a manually operated tool. For intermediate levels, humans program the tool, observe its operation, and interrupt or reprogram as needed. For the highest level, the machine senses the operation needed, programs itself, and monitors its own operations.

- The ability of the service process to perform its activities without human intervention. Automation can be often achieved by using single or multiple functional devices and systems with advanced technology (e.g. information and communication technology).

39 — Productivity: The number of functions or operations performed by the subsystem or whole technique per unit of time. The time for a unit function or operation. The output per unit of time or the cost per unit of output.

- The ratio of outputs to inputs. In a service process, the outputs are economic results for the service provider and value for its customers. In classic TRIZ, productivity is a concept concerning production efficiency. In service process, it is also influenced by service quality and capacity efficiency.

Appendix B Su-Field Analysis in Services

Su-Field (Substance-Field, S-Field) Analysis, one of the most valuable contributions of TRIZ, consists of Su-Field modeling and 76 standards application. Su-Field modeling is a useful tool of graphically modeling the most important parts of a technical system or technical process and identifying the particular problems in the system or process (Savransky 2000). In this way, the Su-Field modeling maps the specific problems into the generic ones, and the 76 standards provide clear instruction for how the initial model should be transformed in order to solve the generic problems.

Table B-1: Summary of Human Fields
(Source: Belski, 2007)

Field Essence	Filed Name	Interaction	Content
Information (Intangible)	Senses	Vision	color, shape, movement
		Taste	Pleasant, bland, Unpleasant
		Smell	charming, appetizing, neutral, bad
		Hearing	pleasing, dramatic, dull, pleasant
		Touch	pleasant, electrifying, neutral, painful
		Heat	hot, pleasant, cold
		Pain	high, medium, none
		Balance	normal, abnormal
		Body Awareness	normal, abnormal
	Verbal communication	Route	peripheral, central
		Feature	affective, informational
		Organization	time, venue, primacy/recency effect, one-or two-sided argument
		Style	humorous, motivating, educational, threatening, commanding
	Non-verbal communication	Visible	facial expression, gesture, posture, appearance
		Paralinguistic	pitch, loudness, rhythm, inflection, voice quality
		Written	information (true or rumor), request, command, complaint, threat
		Pictorial	picture, sign, puzzle, movie
Material Possession (Tangible)	Real material possession	Money	given or taken
		Valuables	given or taken
		Authority	given or taken
	Perceived material possession	Money	given or taken
		Valuables	given or taken
		Authority	given or taken

Generally, a problematic Su-Field model can be classified into two categories: a) incomplete model with any of the three elements missing and b) completed model with harmful, insufficient or excessive interactions. For the first kind of models, the solution is very direct, i.e. completing the incomplete Su-Field model by adding the missing elements. For the second category, diverse solutions extracted from 76 standards can be used. However, although the many solutions in 76 standards were originally developed to solve the inventive problems, 76 standards have been expanded and encompassed parts of other TRIZ tools such as 40 Inventive Principles, Evolution

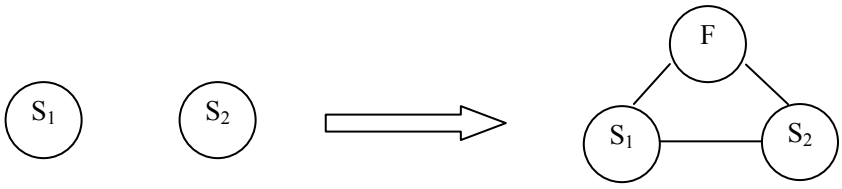
Trends and Effects. This mixture and complexity often confuse TRIZ users and lead them away from the Su-Field Analysis. To improve the usability of Su-Field Analysis, some researchers have removed some standards which cannot be modeled as Su-Field, and then condensed or generalized the solutions for Su-Field Analysis (Belski 2007; Mao et al. 2007; Soderlin 2003).

In Su-Field model, the term "Substance" can be a material object of any level of complexity. The substance can be a single element as well as a complex system or process. An effective complete Su-Field model has two indispensable substances - "tool" and "object" which are respectively denoted by S_2 and S_1. The term "Field", in broad sense, can be any interaction between substances that yield the required outcome. Therefore, Su-Field analysis has been also successfully applied in the non-technical areas (Belski 2007; Kappoth and Goolya 2008). It is also possible to apply the Su-Field Analysis for the service process design and improvement. In the service context, the object often refers to a customer who receives the service results or experiences, while the tool can be any of employees or facilities within the service provider company. Field is every possible communication channel or way in which the service supplier and the customer interact. Belski (2007) summarized "Human" fields which could be useful in the service context.

Some examples in a service process involving the customers are provided for the generalized solutions. For all the models illustrated below, S_1 denotes the customers, and S_2 denotes the front-office or back-office employees or facilities. The drawing lines connecting two substances could be

a. Solid, indicating no problem
b. Dotted, indicating inadequate field or interaction
c. Corrugated, indicating excess or problem in interaction.

(1) Complete an incomplete Su-Field models

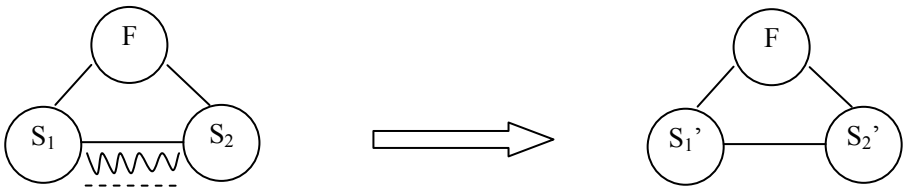


Example:

- *Make the back-office employee's actions visible or sensible to the customers. The fast food preparation process and hygienic workplace visible through the glass bring positive impact to the customers.*

(2) Modify one of the existing substances.

- Change the one of the substances into another form, or add an additive to one of the substances. The modification can be temporarily or permanent from internal or external environment.
- Increase the segmentation of one or both of the substances.
- The substances can be made dynamic.

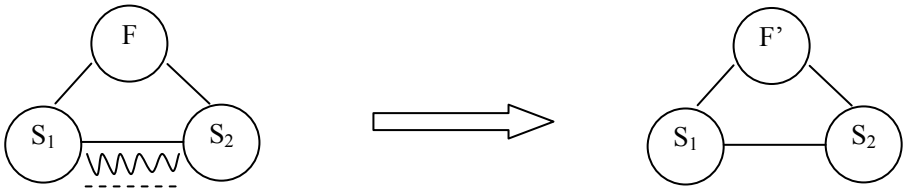


Examples:

- *Customers can be segmented based on their needs (Segmentation)*
- *Service firms invest in training and empower their contact personnel to have discretionary power in delivering services (Chai et al. 2005) (Dynamic)*
- *Design the human personality into routinized self-service system such as persona design in UBS company (Salomann et al. 2007). (Add an additive)*

(3) Modify the existing field

- Increase, decrease the existing field, or completely replace it with another one.
- The field can be made dynamic.

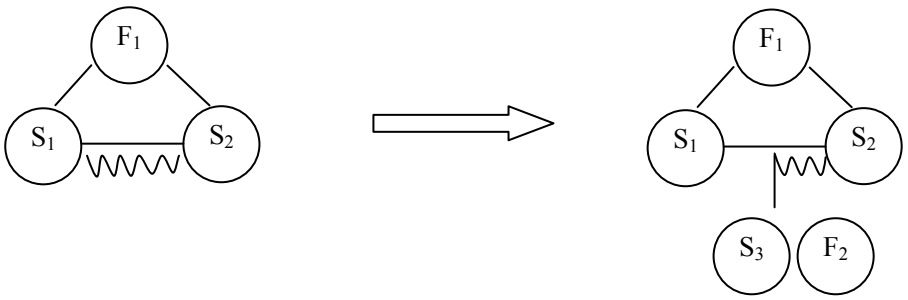


Example:

- *Entertainment services such as Disney theme parks often dedicate to enhancing their culture exposure to their customers.*

(4) Add a new substance or field between tool and object

- If the harmful interaction exists, and the substances S1 and S2 have to coexist (e.g. useful interaction between S1 and S2 exists), the problem is solved by adding a new substances between the tool and object, or
- Adding a new field which can either be a counteractive field to remove or reduce the harmful interaction, or a positive field to increase useful effect and reduce the negative effect).

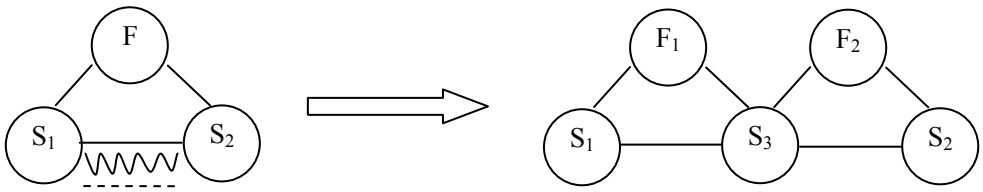


Examples:

- *Restaurants add the pictures to the menu items to avoid the misunderstanding of some dishes with confusing name. (Add vision sense as a new field to reduce the harmful effect)*
- *The service firms offer different ways (NETS, Visa) addition to by cash for payment. (Add new field to enhance the useful effect)*
- *Banks set up the security glass between customer and contact personnel to prevent potential crime. (Add new substance to eliminate the harmful effect)*
- *Teachers use amplifier to increase their volume in a large lecture theater (Add new substance to enhance the useful effect)*

(5) Expand existing Su-Field model to a chain

- Introduce a new substance S3 between the original substances S1 and S2, so the S1 and S2 will interact indirectly via the S3.

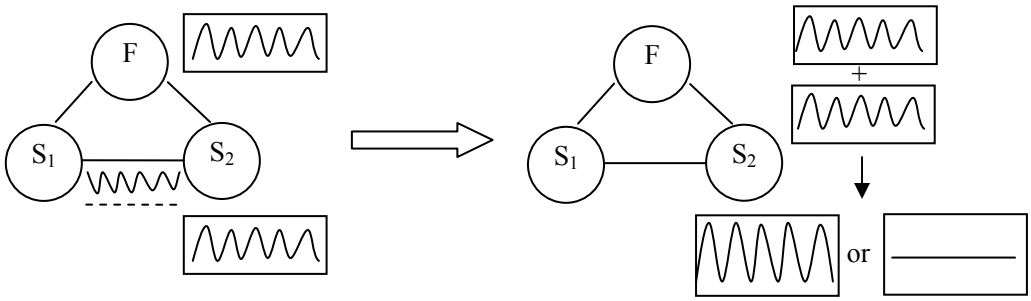


Examples:

- *Hospital establishes the call center to facilitate the customers to consult or make appointment instead of letting them directly call the clinic or department to do so.*
- *Service firms may outsource the services or appoint agents to fulfill the customer requirements, e.g. airline companies often have many travel agents to sale tickets.*

(6) Match (mismatch) the rhythms in the system

- The frequency of field can be matched or mismatched with the substances



Example:

- *Appropriately determine the number of available counters according to the customer arrival rate during each period.*

Appendix C Web Survey Questionnaire

This survey lists some common problems occurring in restaurant service process. Based on your own experience, you may choose and/or specify additional answers.

The questionnaire will take you approximately 20 minutes to complete. As the questionnaire is highly unlikely to list all problems, it will be very helpful for you to add other problems you encountered. Your time and honesty are highly appreciated.

1. What is the type of restaurant?

- ○ Fast-food restaurants
- ○ Fast casual-dining restaurants
- ○ Casual dining
- ○ Fine dining
- ○ Other, _____

2. What is your role in the restaurant service process?

- ○ Customer
- ○ Service provider

Please proceed to question 2 if you choose "customer", and proceed to question 3 & 4 if you choose "service provider"

3. What are the problems you often encounter in the restaurant? (You may choose multiple answers to this question. It will be very helpful for you to add answers to each question. When you choose or add an answer, please specify its severity and frequency of occurrence.)

Degree of severity: 1 – least severe, 5 – most severe
Frequency of occurrence: 1 – least frequent, 5 – most frequent

What are the problems you often encounter during the reception?

	Problems	Examples	Severity	Frequency
☐	Employees with poor attitude	No greeting, Employees show an attitude of indifference, or treat like my business is not important, etc.	1 2 3 4 5	1 2 3 4 5
☐	Long waiting time for table	Long queue for table	1 2 3 4 5	1 2 3 4 5
☐	Reservation missing	The reserved table is occupied by others	1 2 3 4 5	1 2 3 4 5
☐	Others, please specify			

What are the problems you often encounter during the order placement?

	Problems	Examples	Severity	Frequency
☐	Waiters with poor attitude	Waiters show an attitude of indifference, Treat me like my business is not important, No greeting, etc.	1 2 3 4 5	1 2 3 4 5
☐	Long waiting time for order placement	I am kept waiting long time for waiters, waiters are too busy to serve me	1 2 3 4 5	1 2 3 4 5
☐	Waiters' lack of knowledge	Waiters do not know the details of items on menu	1 2 3 4 5	1 2 3 4 5
☐	Out of stock	Items on the menu are sold out	1 2 3 4 5	1 2 3 4 5
☐	Others, please specify			

What are the problems you often encounter during food serving?

	Problems	Examples	Severity	Frequency
☐	Waiters with poor attitude	Waiters show an attitude of indifference, Treated like my business is not important, etc.	1 2 3 4 5	1 2 3 4 5
☐	Food defects	Food is cold, soggy, contains hair etc.	1 2 3 4 5	1 2 3 4 5
☐	Long waiting time for food	Long waiting time for dishes	1 2 3 4 5	1 2 3 4 5
☐	Food not cooked to order	Serving other one's food to me, food is not cooked as I request	1 2 3 4 5	1 2 3 4 5
☐	Order misplaced or never filled	I am not served food I ordered	1 2 3 4 5	1 2 3 4 5
☐	Out of stock	Food cannot be served after order placement	1 2 3 4 5	1 2 3 4 5
☐	Others, please specify			

What are the problems you often encounter during payment?

	Problems	Examples	Severity	Frequency
☐	Employees with poor attitude	Showing an attitude of indifference, Treated like my business is not important, etc.	1 2 3 4 5	1 2 3 4 5
☐	Unclear, guest unfriendly policies	Like not accepting cheques or credit cards	1 2 3 4 5	1 2 3 4 5
☐	Incorrect charges	charging customers for items not ordered or	1 2 3 4 5	1 2 3 4 5

		give incorrect change		
☐	Others, please specify			

4. What is your position in the restaurant?
- Receptionist
- Casher
- Waiter/Waitress
- Chef or cook
- Manager
- Director
- Other ____

5. What are the problems you often encounter in providing services to your customers? (You may choose multiple answers to this question. It will be very helpful for you to add answers to each question. When you choose or add an answer, please specify its severity and frequency of occurrence.)

Degree of severity: 1 – least severe, 5 – most severe
Frequency of occurrence: 1 – least frequent, 5 – most frequent

What are the problems on the physical or human capacity you often encounter or find in your restaurant?

	Problems	**Examples**	**Severity**					**Frequency**				
☐	Seating capacity	Customers wait for long time for seats	1	2	3	4	5	1	2	3	4	5
☐	Employee capacity	Not enough employees to serve customer	1	2	3	4	5	1	2	3	4	5
☐	Kitchen capacity	Too busy in preparing food	1	2	3	4	5	1	2	3	4	5
☐	Customer loss	Customers quit the long queue, or decide not to join the long queue	1	2	3	4	5	1	2	3	4	5
☐	Others, please specify											

What are the employee problems you often encounter or find when providing service to customers?

	Problems	**Examples**	**Severity**					**Frequency**				
☐	Lack of knowledge and skills	Unable to explain menu items to customers, unable to cook menu items	1	2	3	4	5	1	2	3	4	5
☐	Contact employee errors	Place wrong order, serve wrong dishes, give incorrect changes, etc.	1	2	3	4	5	1	2	3	4	5
☐	Unfriendly employee behavior	rudeness, poor attitude or attention	1	2	3	4	5	1	2	3	4	5

☐	Role conflict and role ambiguity	Work under vague directives or orders, receive incompatible requests from two or more people	1 2 3 4 5	1 2 3 4 5
☐	Others, please specify			

What are the service delivery problems you often encounter or find when providing service to customers?

	Problems	**Examples**	**Severity**	**Frequency**
☐	Customer complaint on food quality	Food is cold, contains hear, insects, etc.	1 2 3 4 5	1 2 3 4 5
☐	Out of stock	like inadequate supply of menu items	1 2 3 4 5	1 2 3 4 5
☐	Customers not met restaurant policies	Bring outside food, cannot pay cash, etc.	1 2 3 4 5	1 2 3 4 5
☐	Others, please specify			

Appendix D Sample Interview Questionnaire

1. Can you describe the activities involved in your service process from customer arrival to customer leave? (Probe more details during the conversation)

2. What are the most important objectives your restaurant currently wants to achieve? (Please prioritize these objectives)

a. Profitability
b. Cost effective
c. Efficiency

3. How many employees are working in your restaurant? (Probe more details regarding employee structures)

4. What recruitment channels do you use to hire new employees? (Probe questions such as which is the most effective, what are the difficulties in hiring employees?)

a. Placing ads on newspapers
b. Placing ads on popular online job portals and restaurant's website
c. Looking for services from commercial recruitment agencies
d. Employee referral schemes

5. What are the screening criteria do you use when hiring new employees?

6. How is the employee turnover rate in your restaurant? Is it high or acceptable?

7. From your experience, what are the factors contributing to the employee turnover?

a. Salary level
b. Work load
c. Career advancement
d. Management support

8. What kinds of incentives or motivations do you provide to employees to increase employee loyalty?

a. Monetary compensation
b. Promotion
c. Training and learning
d. Teamwork culture

9. What are the marketing tactics or promotion ideas currently used in your restaurant?

a. Traditional advertising on TV, radio, & newspapers,
b. Bounce backs – offer incentives to customers to bounce guests from peak times to off-peak times.
c. Business socials – select the right group to partner with to leverage their resources to promote your restaurant.

10. Which costs listed below is high for your daily operations (what are the reasons resulting in the high cost)?

a. Human resource cost
b. Raw material cost
c. Utility cost
d. Facility maintenance

11. What are the cost reduction measures in your restaurant?

12. What are the symptoms, problems, or customer complaints (feedback) you observed or received regarding current services in your restaurant? (For examples)

(1) Long waiting time for table/food
Degree of severity: 1-----2-----3-----4-----5
Frequency of occurrence: 1-----2-----3-----4-----5
What are the possible causes of this problem?
a. Not enough seats and dining tables
b. Not enough kitchen facilities
c. Not enough kitchen staff
d. Too many customers during peak hours
e. Others_____

(2) Contact employees/waitresses with poor attitude (not attentive, slow, or not courtesy)
Degree of severity: 1-----2-----3-----4-----5
Frequency of occurrence: 1-----2-----3-----4-----5
What are the possible causes of this problem?
a. Lack of employee empowerment to deal with exceptions
b. Not enough employees during peak hours
c. Deficiencies in employee recruitment
d. No formal procedures for service recovery
e. Others_____

(3) Inconsistence of food quality
Degree of severity: 1-----2-----3-----4-----5
Frequency of occurrence: 1-----2-----3-----4-----5
What are the possible causes of this problem?
a. Turnover of kitchen staff
b. Lack of supplier quality control
c. Malfunction of the storage equipment
d. Others_____

(4) Others (Is there any other problem?)

13. What are the resource limitations that prevent you from solving the problems we discussed earlier?

a. Lack of money
b. Lack of human resource
c. Lack of time
d. Lack of space
e. Lack of knowledge
f. Others_____

Case Restaurants

Restaurant A: Dian Xiao Er Restaurant (Jurong Point outlet)
Interview date:
Interview venue: in restaurant, #03-26/27 Jurong Point
People interviewed: Duty manager

Restaurant B: Nanxiang Steamed Bun Restaurant (Bugis Junction outlet)
Interview date:
Interview venue: in restaurant, 200 Victoria Street #02-53 Bugis Junction
People interviewed: Branch manager

Restaurant C: Fortune Restaurant (Xin Fu Yum Cha) (Orchard outlet)
Interview date: 2010-04-17
Interview venue: in restaurant, 360 Orchard Road
People interviewed: Branch manager

Restaurant D: HK Kim Gary Restaurant
Interview date:
Interview venue: in restaurant, 1 Harbourfront Walk, #02-128 VivoCity
People interviewed: Duty manager

Restaurant E: Formosa Delights (West Coast outlet)
Interview date:
Interview venue: in restaurant, 154 West Coast Road, #B1-53 West Coast Plaza
People interviewed: Branch manager