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A Complexity Management Approach for Designing Viable IT Service Systems in South Africa

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfilment of the requirements for the degree of Masters of Science in Engineering.

09 October 2019

Declaration

I declare that this research report is my own, unaided work. It is being submitted for the Master of Science degree in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.



09 October 2019

Abstract

This research investigates important determinants in designing, implementing and managing viable Information Technology (IT) service systems in the South African economy where digitalisation and globalisation are introducing unprecedented market and technological dynamics. The research adopts the Viable Systems Approach to provide a systematic, iterative process to service system design, tackling both service delivery and service co-creation complexities through the application of Viable System Theory. Having identified and discussed various existing service system design models available in the literature to date, the residual complexities these models present are discussed, and the research proposes an integrated model for designing viable IT service systems. The developed Integrated Service System Model is used for developing a complexity management approach to designing viable IT service systems within selected firms in South Africa.

The finding is that the Viable Systems Approach efficiently reveals residual variety in operational IT services systems under investigation while also providing viable service system designs for services systems found to contain a residual variety. The use of the Cybernetics model within the Viable Systems Approach proves useful in analysing specified service system viability operating in dynamic markets by providing the analytical tools and methods to interrogate systemic behaviour from a complexity perspective.

The recommendation is that in erratic dynamic markets where previous performance history does not guarantee sustainable performance, residual variety presented by the market environment and the ability to effectively implement viable service system designs are critical determinants to designing viable IT service systems that can survive in the digital economy. The implications for management is the foundational understanding and a multi-disciplined application of Organisational Cybernetics (OC) in the design and management of service systems. Further research is suggested in applying the developed Integrated Service System Model in other industries and service system context to prove or improve the tenacity of the model in designing service system that adapts to dynamic market environments over the entire service system lifecycle.

Publications

Mokgala, M. and Emwanu, B. (2018), A Complexity Management Approach to Designing Viable IT Service Systems in South Africa, Proceedings of the International Conference on Industrial Engineering and Operations Management, Pretoria, South Africa, October 29 – November 1 2018, IEOM Society International, United States of America

Dedication

To my parents
David Dinake Mokgala and Florah Sewela Mokgala
for their love and support.

Acknowledgements

I want to thank Dr Bruno Emwanu for his supervision and the support and outstanding guidance and support he provided over the past years. More than anything, I appreciate the potential and faith he placed in me, which has become my source of inspiration.

I would also want to thank the companies with which I conducted this research for availing their valuable personnel, most of whom are at senior strategic levels of management and possess decades of industry expertise.

Sekhwela Moses Mokgala

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List of Terminologies

Term	Definition
API	In computer programming, an application programming interface (API) is a set of subroutine definitions, systems communication protocols, and tools for building software systems integrations.
ASM	Abstract State Machine is a systems engineering technique used to analyse systems by representing them as a set of states and transitions rules between states.
B2B	Business to business channel
B2C	Business to end customer channel
Co-creation	The process by which products, services and experiences are jointly developed by companies, their partners and the final customer, leading to a new space where the value created can be shared.
Complexity	The number of distinguishable, dynamic states in a system over time.
Digital Transformation	A process in which an organisation is shifted to new ways of working and thinking with digital and social technologies.
Digitalisation	The integration of technologies into everyday life by the digitisation of everything that can be digitised.
Homeostasis	Stability of the systems internal environment despite the system's having to cope with an unpredictable external environment.
Homeostatic Loop Analysis	A check for the four principles of organisation and is the basis for Variety Engineering.
Hybrid IT Infrastructure	Approach to enterprise computing in which an organisation provides and manages some information technology (IT) resources in-house but uses cloud-based services for others. A hybrid approach allows an enterprise to maintain a centralised approach to IT governance while dealing with cloud computing.
IaaS	Infrastructure as a Service (IaaS) refers to online services that provide high-level APIs used to dereference various low-level details of underlying network infrastructure like physical computing resources, location, data partitioning, scaling, security, backup etc.
ICT	Information and Communications Technology
ISV	Independent solution or software vendor
IT	Information Technology. A branch of engineering that deals with the use of computers and telecommunications to retrieve, store and transmit information.
IT services aggregation platform	This is a digital platform that allows the consolidation and dispensing of IT services and organisational capabilities to customers and partners through the internet.
Law of Requisite Variety	Only variety can absorb variety.
PaaS	Platform as a Service (PaaS) is a category of cloud computing services that provides a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure typically associated with developing and launching an app.

Residual Variety	Variety not dealt with by the environment in which the systems operates or within the operational systems itself and has to be catered for in the management system managing the operational system.
SaaS	Software as a service (SaaS) is a software licensing and delivery model in which software is licensed on a subscription basis and is centrally hosted.
SVN	Service Value Network
Variety	The number of all the possible states of a system.
Variety Engineering	The engineering of mechanisms into a system that ensures the balance of variety between the system being controlled and the management of the system ensuring no residual variety
Vendor	A vendor, or seller, is an enterprise that contributes to goods or services. Generally, a supply chain vendor manufactures inventory/stock items and sells them to the next link in the chain. In the case of the South Africa IT industry context vendors and original manufacturers of equipment and software.
Viable	A system is viable if it can maintain existence in a particular sort of environment.
Viable Systems Approach	Systems theory in which entities are observed in their natural environment and interpreted through a systemic viewpoint, beginning with fundamental elements to considering complex system characteristics.
Viable System Model	A model for designing organisational units of viability.
Viable Systems Theory	Systems theory which concerns cybernetic processes concerning the development and evolution of dynamic systems considering them as living systems that are complex and adaptive.
Transducer	A conceptual representation of encoding and decoding variety crossing a boundary between two systems. A transducer expresses a variety information in different formats and modes.

1. INTRODUCTION

During the last few years, the information technology (IT) industry, along with other industries globally, has been transforming as a result of globalisation and digitalisation (Chungunov et al., 2016). Investments in digital transformation initiatives and formations of coalitions for introducing new digital offerings characterise the industry transformation in response to the emerging digital economy and technological advancements driving the realisation of networked cyber-physical systems (Chungunov et al., 2016; Rossignoli et al., 2018). These transformations present many challenges, and as a result, are tackled in coalitions to accelerate innovation and time to market (MacGregor and Tamara, 2012; Rossignoli et al., 2018).

Amid these transformations, organisations have come to realise that new thinking and approaches leveraging technology advancements are required to realise sustainable business models that are to survive in a complex, tightly networked, and dynamic market environment (Hanna, 2010a; Oswald and Kleinemeier, 2017; Rossignoli et al., 2018). The question of whether models or frameworks exist contrary to traditional models for defining and designing business models capable of surviving in the proliferating digital economy remains open (Raisch, 2004; Burton and Obel, 2004; Oswald and Kleinemeier, 2017).

1.1 Research Background and Context

"A system is viable if it can survive in a particular environment." (Beer, 1985, p. 1)

The South Africa IT industry is undergoing a rapid ecosystemic reconfiguration (Kneale, 2016). The reconfiguration is a result of proliferating digital transformation across the entire global IT industry, as presented in the International Data Corporation (IDC) Vendor Spotlight whitepaper of May 2018 (Adam and Breeze, 2018). IT distributors investing in platforms and e-commerce systems; companies investing in digital skills to build the digital enterprise; mergers and acquisitions; and resellers requiring application programming interfaces (APIs) to automate transacting with distributors are some of the characteristics of this transformation (Kneale, 2016). The rapid industrial digital transformation is attributable to advancements in cloud technologies and internet enabling cost-effective digital business-to-business transacting, IT vendors mandating digital transformation downstream in the distribution channels, and end customers demanding customizable digital experiences for consumer products and services (Adam and Breeze, 2018).

Traditional IT distributors find themselves challenged in the centre of these IT ecosystems having to redefine their value in the digital economy. This is a paradigm shift in how value is defined.

The paradigm shift challenges traditional business models and is reconfiguring the IT industry to a service-oriented ecosystem, as demonstrated in Figure 1. Value is co-created with consumers through the interaction with service providers rather than the traditional selling of products. Note that this is represented in Figure 1 by a singular flow of intellectual value creation in the traditional configuration as opposed to the multidirectional flow of intellectual value creation in the service-oriented configuration. In the latter configuration distributors become a vendor-interdependent dispenser of services while co-creating value with partners, as opposed to traditional distribution, commonly termed as 'box - dropping'. To do this, distribution has to deliver unique market-relevant service aggregation at digital economies of scale to remain relevant in the ecosystem. This transformation entails the digitalisation of traditional competencies and capabilities while leveraging digital technologies in the organisation at all levels of the organisation (Oswald and Kleinemeier, 2017). As a consequence, resource allocation is based on the consumption of service inter-industries as opposed to traditional silo product-oriented selling (Khosrow-Pour, 2018). These changes present challenges not only at the industry level but within organisations as well (Hanna, 2010a; Angela, 2017).

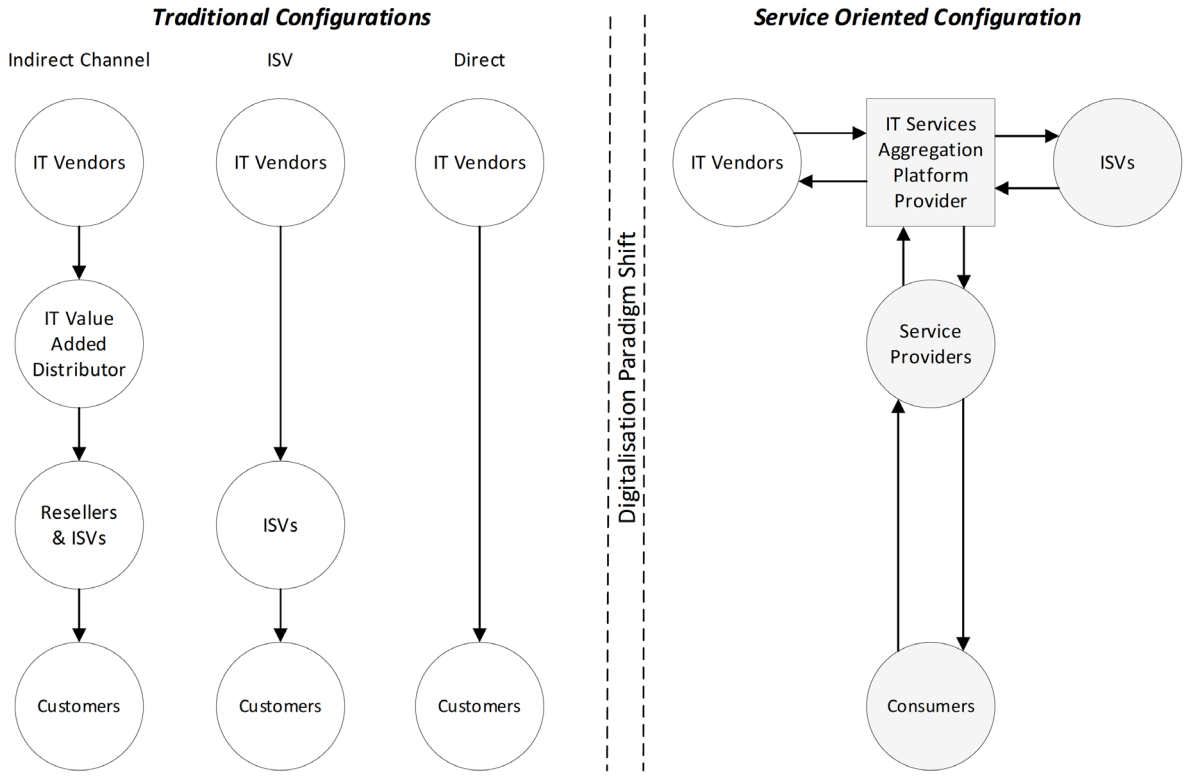


Figure 1: SA Industry Configurations Reconfiguration (Adam and Breeze, 2018).

An IT Vendor, in Figure 1, is a common term used in the industry referring to the original manufactures of IT software and hardware products (Kneale, 2016). Many of these software vendors are internationally based, such as Microsoft, Cisco, Oracle, IBM, Dell and HPE, just to name a few. In this research pseudo names such as Vendor 1, Vendor 2 is used to protect the identity of the companies and the interviewees. The primary function of these Vendors are the designing and manufacturing of hardware, software products and IT service (PaaS, IaaS, SaaS) either delivered directly to end customer or indirectly through a partner channel. They are also commonly referred to as original equipment manufacturers (OEMs). End users are usually made aware of a Vendor through an end-user agreement from the Vendor contained in the product packaging specifying the terms of use. A digital counterpart of this is when acknowledging the end-user agreement before downloading or installing the software.

Cloud computing technology advancements over the decades have enabled vendors to package some of their software and hardware products as services, namely, Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a service (IaaS) and Information Technology as a service (ITaaS). Each is attracted to a specific consumer profile in mind. With increased internet advancements, the vendor is enabled to sell and service customers globally through e-commerce portals, digital platforms and web-based applications (Kneale, 2016). A customer can buy cloud services, download the applications and receive software updates at a click of a button. This has allowed direct and indirect models of software and hardware distribution to customers globally.

Notably, an emerging service in the industry is Information Technology as a Service (ITaaS). ITaaS is an operational model within an organisation that provides remote expertise, support and management of information technology for other organisations. This service allows the outsourcing of entire IT departments to other companies. Below are the types of IT services that are available in the South African IT industry with their descriptions.

Software as a Service (SaaS)

"SaaS means the software is available on-demand, most of which is browser-based and dedicated to a specific function. SaaS applications are often priced by a rental fee, which includes the application software license fees, software maintenance and technical support costs." (Khosrow-Pour, 2018, p. 457)

Platform as a Service (PaaS)

"PaaS provides a hosting platform in which users are allowed to develop applications without dealing with software issues such as operating system upgrades, implementation of compilers, installation and maintenance of databases." (Khosrow-Pour, 2018, p. 457)

Infrastructure as a Service (IaaS)

"IaaS provides suitable hardware, including physical servers and network bandwidth services directly to the end-users who do not own enough processing power, storage capacity, applications to meet the needs. These resources can be 'rented' from a cloud provider on an as-needed basis and accessed from anywhere via an internet connection. Cloud services employ a metering system that divides the computing resources into appropriate blocks and users pay for the service as an operating expense without incurring any significant initial capital cost." (Khosrow-Pour, 2018, p.456)

Information Technology as a Service (ITaaS)

"ITaaS is an operational model where the information technology service provider delivers an information technology service to a business. The IT service provider can be an internal IT organisation or an external IT service company. The information technology is typically delivered as a managed service with a clear IT catalogue and pricing associated with each of the catalogue items." (Amir and Rusli, 2013)

In the section that follows traditional configurations are considered where indirect, direct and service-oriented channel models are discussed.

1.1.1 Traditional IT Distribution Channel Models in South Africa

In an indirect channel model, vendors sell their products to value-added distributors (VADs) that resells to end customers through a reseller community. The reseller community consist of major retail stores to small, privately owned stores selling specific products with tailored services to their end customers. This model allows a Vendor to reduce their overheads in support costs and delivery of products while maintaining the quality of delivery to different regions in the world. VADs scale the delivery of IT products and services into geographical regions; this is their primary value proposition in the industry. As a result, a VAD is certified and promoted as a distributor of choice having attained the relevant skills to support the Vendors products and enjoys discounted product

volume pricing in return with reserved distribution rights from the Vendor.
In another configuration, an independent software developer (ISV) will buy a development platform directly from a Vendor. This is an example of a direct channel model. An ISV uses development platforms to develop software solutions for customers. An example is a private company that provides animal tracking technology to a farmer or a nature reserve. A software application is provided to the farmer enabling the farmer to track animals remotely. Such a solution is often developed on tools and software purchased from a Vendor directly, and therefore; payment is made directly with the Vendor. An ISV might look for better pricing, product support and convenient payment options and may decide to buy indirectly, through a recommended locally available VAD instead.

In another direct channel model, an end customer buys directly from a vendor. A good example is buying software online using a credit card or purchasing a laptop directly from HP. Some website prohibits this in certain countries by recommending a reseller or distributor 'near you'. Each of the configurations has its benefits and risks from the perspective of both the end customers and the Vendors. However, traditionally, these channels have been silo product sales driven rather than service driven.

The next section describes a service-oriented distribution channel configuration emerging in South Africa.

1.1.2 The Service-Oriented Distribution Channel Models in South Africa

A service-oriented configuration promotes the co-creation of value with customers (Maglio et al., 2019). Service orientation transforms traditional product selling business models into service systems (Demirkan et al., 2011b, pp. 1–2). The concept of a service system is derived from Service Science. Service Science is the study of the co-creation of value with other service systems and individuals, which all possess complex evolving needs (Demirkan et al., 2011b, p. 35; Maglio et al., 2019, p. 2). 'Simply put, service science combines organisation and human understanding with business and technology understanding to explain and design service systems, busting silos along the way' (Maglio et al., 2019, p. 2).

Service Systems possess the structural qualities to adapt dynamically to evolving value propositions (Demirkan et al., 2011b, p. 73; Maglio et al., 2019, p. 2). Service systems have the potential of

improving states of other service systems by sharing resources and outsourcing capability for delivering systemic value (Maglio et al., 2019). On the other hand, services delivered by service systems can disrupt or render other service systems irrelevant (Maglio et al., 2019). The service system concept provides a fitting framework for conceptualising the configuration presented as a service-oriented configuration indicated on the right of Figure 1. This new configuration, when defined as a service system, can be studied and diagnosed using approaches from service science and design.

One example is a service design approach that first identifies key dimensions of a service system as in Figure 2. In this case, a service system can be analysed in the four key dimensions of a service system namely, customers, technology, information and people (Demirkan et al., 2011b, p. 41). Such a definition valuable, but what is not reflected in Figure 2, which is pertinent to a service system by definition, is other service systems that co-exist around the service system and the possibility of synergistic relationships. The inference could be in the information sharing between service systems but what is not evident is how other service systems impact on the service system along with its market size.

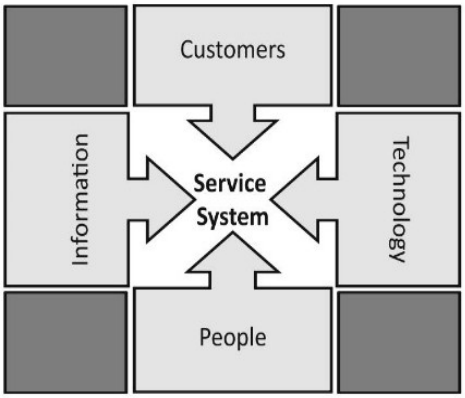


Figure 2: Key Dimension of Service Systems (Demirkan et al., 2011b, p. 41).

While Figure 2 is one example of a service system framework, other frameworks available in the literature will also be reviewed in this research. The example above demonstrates that although various frameworks exist for designing service systems, there is still a need for a systemic, comprehensive approach to designing IT service systems from a holistic perspective taking into consideration ecosystems of surrounding service systems and implications on market dynamics. These frameworks are explored further in the literature review.

1.1 Problem Statement

Traditional organisation design methods do not suffice in designing complex IT service systems that are sustainable in the evolving digital economy of South Africa (Maglio et al., 2019). To date, IT Services have been designed as silos of products rather than services, thus constituting limited value co-creation from a customer or limited understanding of market dynamics created by surrounding service systems. In the digital economy, value co-creation with customers proves to be a core capability in differentiating against the competition (Karat et al., 2004; Oswald and Kleinemeier, 2017). The reality that organisations face with the evolutionary digital economy is that disruption can come from anywhere at any time (Maglio et al., 2019). Traditional product-oriented organisational design methods that focus primarily on the internal organisational capabilities assume stable market environments over product lifecycles (Metcalfe and Cantner, 2003; Raisch, 2004).

The traditional product-oriented organisational design approach might not be suitable for designing service systems in dynamic markets (Akkermans, 2018; Maglio et al., 2019). Although services are becoming dominant modes of generating value in the economy, their dynamics are still rarely understood making it difficult in designing viable service systems that survive in dynamic markets presented in the IT industry where information technology innovations and e-Transformation (Hanna, 2010b) are fundamentally changing how IT services are communicated, offered, delivered and consumed (Akkermans, 2018; Maglio et al., 2019). Cybernetics and Complexity Science are proposed for researching system designs which promote co-creation of value in dynamic environments.

1.2 Research Question

What are the most relevant determinants in designing viable IT service systems for the digitally transforming IT industry of South Africa?

1.3 Research Objectives

In providing the relevant determinants, the research has the following objectives:

1. to determine the state of viability in current IT service systems in selected firms in South Africa

2. to provide a conceptual design for viable IT service systems in selected firms in South Africa

The next sub-sections elaborate on the research objective noted.

1.3.1 Expanding on Determining the Viability State of current IT Service Systems in selected firms in South Africa

This research selects specific operational IT services in South Africa for determining their state of viability. The selection is made, taking into consideration the services delivered by the service system and the market environment. The scope of the study considers the existing IT service types, namely SaaS, PaaS, IaaS and ITaaS delivered through several available delivery channel configurations.

A delivery channel configuration is to be understood as a unique arrangement of the entities, Vendor, ISV and an IT Services Aggregation Platform for delivering a service to a consumer. One example has been created and presented in Table 1. The table represents possible IT- industry entity combinations for delivering SaaS in South Africa. In the study, these are called IT service system configurations. Other service system configurations in the scope of this study are available in Appendix A.

Table 1: SaaS Service System Configurations

IT service system configuration	Service Type	Vendor	ISV	IT Services Aggregation Platform	Consumer	Supporting from other Service Systems Resources	Service Example
SaaS Service System Configuration 1	SaaS	Yes			Yes		Microsoft Office 365
SaaS Service System Configuration 2		Yes		Yes	Yes		
SaaS Service System Configuration 3		Yes		Yes	Yes		
SaaS Service System Configuration 4		Yes	Yes	Yes	Yes		
SaaS Service System Configuration 5		Yes			Yes	Yes	
SaaS Service System Configuration 6		Yes		Yes	Yes	Yes	
SaaS Service System Configuration 7		Yes		Yes	Yes	Yes	
SaaS Service System Configuration 8		Yes	Yes	Yes	Yes	Yes	

Further information on the analysis tool that is used to determine viability is described in methodology Chapter 4.

1.3.2 Expanding on Providing a Viable Conceptual Design for IT Service Systems in selected firms in South Africa

The Viable Systems Approach (VSA), founded on Viable Systems Theory (VST), is used to develop a conceptual model for designing viable service systems catering for all IT service system configuration noted. The literature review justifies the selection of VSA for designing IT service systems. Upon identifying the service configurations that are in the industry, the research then uses the Viable Systems Model (VSM) to provide viable system conceptual designs utilising the VSM Homeostatic Loop Analysis Charts and the VSM Charts. A sample of each chart is available in Appendix B and Appendix C, respectively.

1.5 Assumptions

The research approach involves multi-disciplinary teams consisting of executive leadership, business unit managers, service engineers, service managers and departmental managers. The assumption that the multi-disciplinary workshop-style approach effectively incorporates enough expertise and experience to facilitate the redesigning of viable IT services system provided the participants are exposed to the correct tools and models to translate their combined knowledge to service system designs within a well-structured systematic process.

1.6 Delimitation

The service selection of this study is based on operational IT services provided by a leading value-added distributor in South Africa. The following delimitations are made:

- This study focuses on the design process of viable IT services systems, while the implementation of the redesigns that are executed are outside the scope of this study.
- This study focuses on utilising complexity management methods born from Cybernetics to drive service system improvements and redesigns.

1.7 Structure of Report

The report is made up of seven chapters. A short description of each chapter is presented below:

Chapter 1: Introduction

Chapter 1 provides some background on the transformation of the IT industry and its proliferated

impact on the South Africa IT industry. It also introduces service system concepts which provide a contextual basis for understanding the paradigm shift that is emerging in the South African IT industry. In the chapter is the problem statement, research question objective and assumptions.

Chapter 2: Literature Review

Chapter 2 contains a literature review on service system design models and frameworks. Each model and framework is discussed identifying its contributions and limitations to designing viable IT service systems. Residual complexities are also identified in each model or framework.

Chapter 3: Conceptual Model

Chapter 3 details the model which is proposed, derived from integrating contributions from the models discussed in the literature review, discusses its approach, method, mechanism and structure.

Chapter 4: Research Design and Method

Chapter 4 details the research method used, including the tools and techniques used in collecting and analysing the data qualitatively. Validity and reliability of measurement are discussed at length in this chapter due to the interdisciplinary nature of the study.

Chapter 5: Results

Chapter 5 contains the results from collecting and analysing the capability and perturbation data in determining the viability of current IT service systems considering the South African IT industry.

Chapter 6: Discussion

In Chapter 6 the results and learnings are discussed focusing on design recommendations uniquely attributable to the application of the VSM model. A conceptual service system design process from a complexity management approach is proposed.

Chapter 7: Conclusion and Recommendations

Contains a summary of the findings in this study and recommendation for possible improvements and further studies to be made.

2. LITERATURE REVIEW

According to the Oxford English Dictionary (Stevenson, 2007), viability is the ability to survive or exist in a particular place or climate. Other dictionaries provide similar definitions, although, Beer (1985) develops qualitative characteristics of viability through the Viable System Model (VSM). Since its inception over two decades ago, the VSM has been used extensively for conceptualising, analysing and redesigning large complex organisations (Takahara and Mesarovic, 2003, p. 5) but despite the numerous successful applications, the VSM is not widely known in professional practices. The limited adoption and use of the model in the profession could be because its concepts are not intuitive to grasp (Ríos, 2012, x), and traditionally organisations have been viewed as hierarchically static institutions prescribing the use of other models (Raisch, 2004).

Legacy business models are challenged when designing organisations fit for the digital economy (Ríos, 2012, p. 11; Maglio et al., 2019). The most significant contributor to this transformation globally has been technological advancements that enable flatter, networked type organisations with a broader distribution of information to all levels of the organisation (Espejo and Reyes, 2011). The VSA, with the use of the VSM, provides a systematic design and diagnostic approach for designing and managing these digital age organisations taking into consideration their dynamic complexity and organisational characteristics (Beer, 1985; Espejo and Reyes, 2011; Ríos, 2012; Maglio et al., 2019).

Service systems are to be designed with viability in mind to ensure they can survive in dynamic economic environments, more so in the digital economy (Toivonen, 2016, pp. 51–67). The service itself needs to be viable and the service system that creates and delivers the service needs to be viable as well (Toivonen, 2016, p. 52). Appreciating the service and service system viability concepts means a design approach can be developed that ensures a service system survivability that is sufficient to generate a return on investment (Toivonen, 2016). Service system survivability is achieved by designing service systems that are capable of delivering a multitude of services and able to adapt to markets (Toivonen, 2016, pp. 51–67). According to several authors, the VSM defines such capabilities that can be designed into any system required to be viable from inception (Ashby, 1958; Beer, 1972, 1985; Harnden and Leonard, 1994).

The VSM proves to consider that services are designed with value propositions for markets in mind (Demirkan *et al.*, 2011b; Maglio *et al.*, 2010; Maglio *et al.*, 2019), which at first appear to

fulfil precise needs or market requirements but the defined value might not be viable in the context of other service systems or services that coexist in the market environment. It is these considerations and opportunities that attract high interest to researchers globally (MacGregor and Tamara, 2012; Toivonen, 2016; Maglio *et al.*, 2019), and as a result, the VSM is not the only approach in the literature related to the design of service system. Other models and framework are available in literature related to service systems design. These models are considered next.

2.1 The Service Delivery Design Framework

Demirkan *et al.* (2011b, p. 225) present a framework which is proposed as a useful tool for conceptualising service design in the context of Service Science Engineering and Management. This is shown in Figure 3. Its focus is to conceptualise the determinants for building service systems from a delivery perspective.

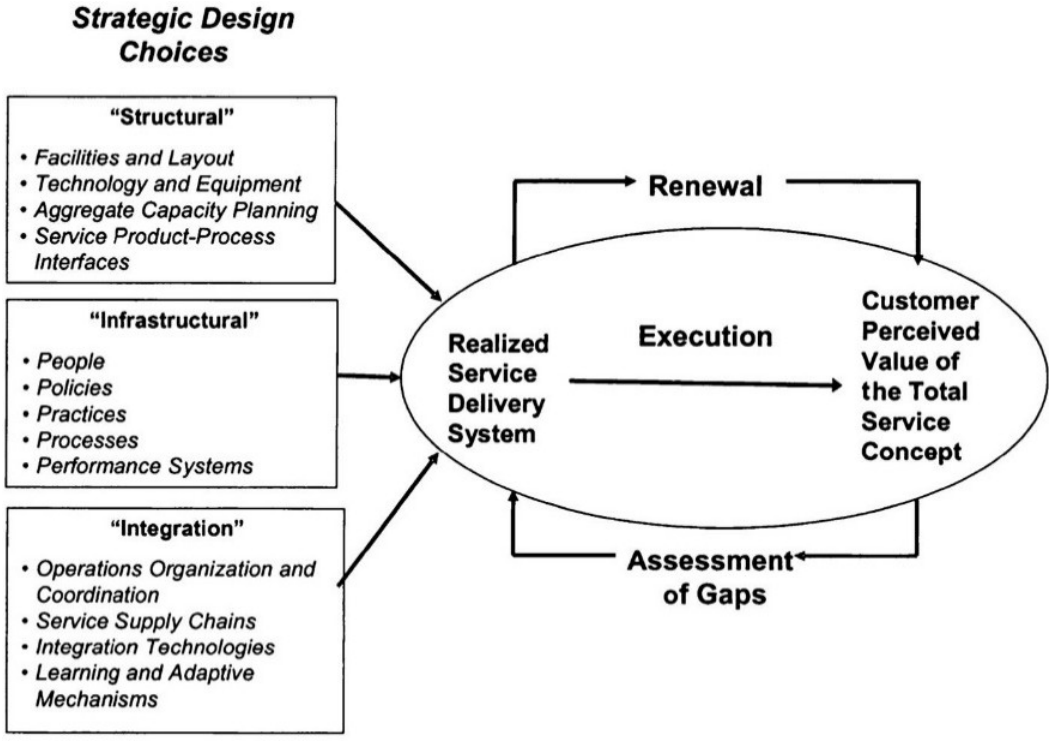


Figure 3: Service Delivery Design Framework Demirkan *et al.* (2011b, p. 225)

While the Service Design Delivery Framework provides the service delivery determinants relevant to the design of service system it does not detail determinants regarding service co-creation and management of complexity from the environment in which the service system exists. Service delivery must be attuned with the dynamics presented in the market and environment in which its services are to be delivered. Although this could be considered in infrastructural strategic design

choices, this is not a once-off design choice since the environment and markets could be dynamic, thus rendering the delivery system irrelevant. In addition to the presented determinants by the Service Design Delivery Framework, this research proposes that there are other crucial determinants when designing viable service systems such as the management of environmental complexity and maintaining synergistic relationships with other surrounding service systems.

Another framework related to the design of services is the Extended Value Co-creation Framework which is described below.

2.2 The Extended Value Co-creation Framework

The Extended Value Co-creating Framework is based on the determinants of value co-creation. This is shown in Figure 4. These determinants include value propositions from the providers and the customers taking into consideration that these value co-creation networks could be set up statically or dynamically from an offerings perspective to either the provider, or customer, or both. (Demirkan et al., 2011b, p. 188).

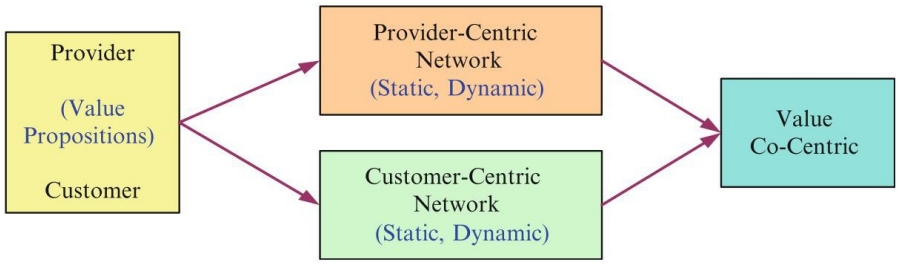


Figure 4: Determinants of Value Co-Creation (Demirkan et al., 2011b, p. 188).

The framework goes further to elaborate based on the determinants and stipulating the scenarios under consideration of service network creation. The framework was developed only to consider the provider-customer co-creation of value, and it only looks at the determinants of co-creation considering providers and customers, a valuable consideration to the determinants to service systems. The framework is valuable for determining the different co-creation configurations that can exist between providers and customers, as shown in Figure 5 (Demirkan et al., 2011b, p. 190).

This framework does not consider other service systems, with their providers and consumers, and the environment within which the service system exists. The service system operating environment is essential because consideration must be made regarding possible competing and

synergistic service systems and their impact on the market. Therefore in addition to the presented determinants by the Extended Value Co-Creation Framework, this research proposes that there are other crucial determinants when designing viable service systems such as service delivery, dynamic collaboration policy development and the management of environmental complexity within the service systems, which are not considered.

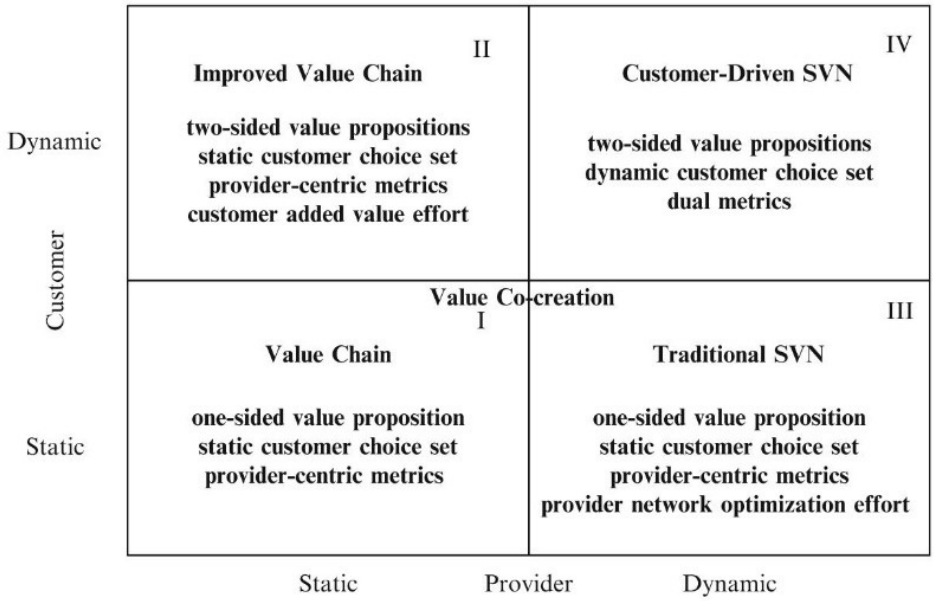


Figure 5: Framework for Extended Value Co-Creation in SVN (Demirkan et al., 2011b, p. 190)

Yet another framework related to the design of service systems is the Service Machine Model described next.

2.3 The Service Machine Model

The Service Machine Model is one of the most recent models to be developed. The model uses an approach of a 'templating' which is used to structure sets of questions to describe and analyse service production systems (Roy et al., 2019). An adaption of the Business Model Canvas is merged into the Service Machine Model to incorporate the definitions of businesses that sustain themselves by providing products and services to market as depicted in Figure 6. The model leverages off precise definitions in the Business Model through structured questions and superimposes this to a universal machine definition to produce a service machine template. The questions in the service machine template guide a system designer to elaborate on the individual blocks of the service machine in a given context. In answering the questions, the service system designer may probe the architecture of the services machine.

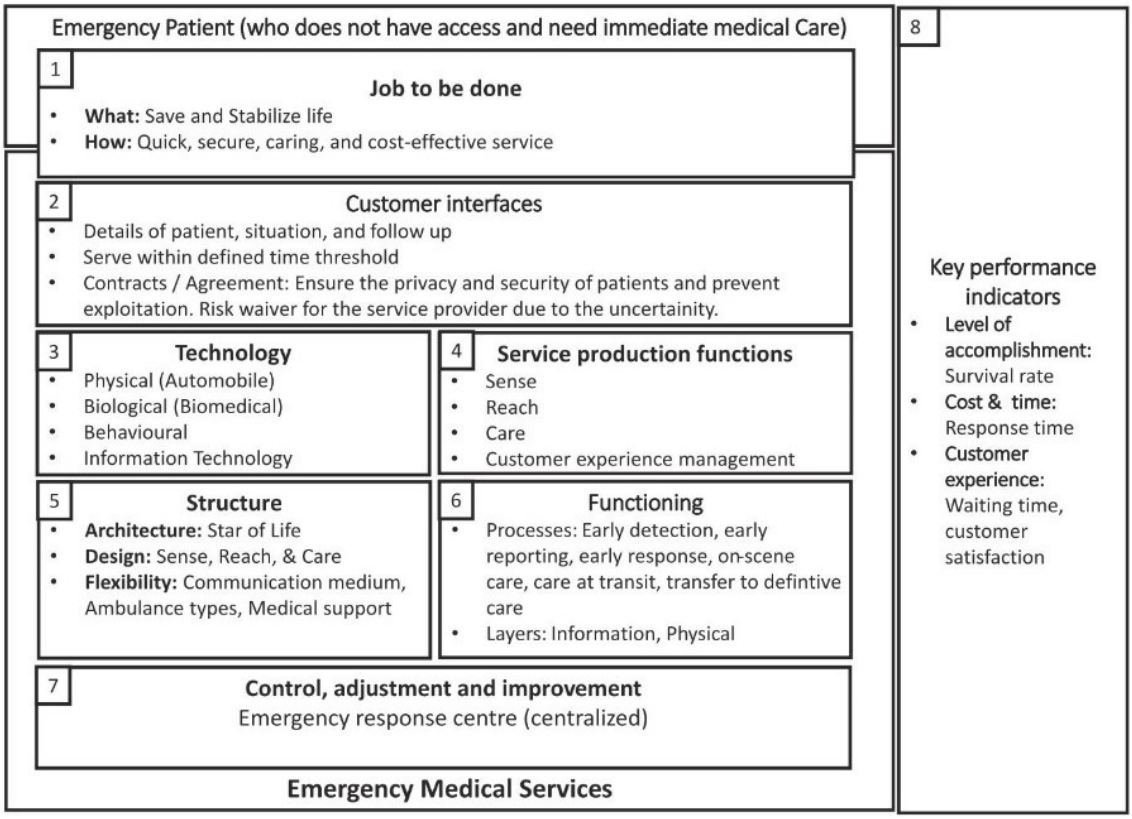


Figure 6: Service Machine Template for Emergency Medical Services (Roy et al., 2019)

The Service Machine Model is a useful tool for formulating the correct question to ask to define the service system but does not detail a systematic design process of the service machines. Neither does it deal with the dynamic relationships between the eight areas in detail. The model, however, provides eight key areas that are to be well defined to constitute a service machine namely, the market need, the service system functions, the resources required, the management control and the key performance indicators (KPIs). The Service Machine Model provides a valuable addition to this research.

Another notable framework in the literature is the Dynamic Research Framework.

2.4 The Dynamic Research Framework

The Dynamics Research Model illustrated in Figure 7 was developed by Raisch (2004) to provide a model leveraging the contributions of different strategic perspectives when viewing the determinants of firm performance. Having critiqued the fragmented nature of traditional business models available at the time, Raisch (2004) developed a framework focusing on defining

determinants that enable firms to manage dynamics complexity for strategically achieving long term performance equilibrium. Raisch (2004) applied the model in the American media industry and had the following to say.

"The integrated model focuses on the long periods of relative stability. Concerning the frame of reference developed above, the integrated model remains equilibrium-based, thus understanding change as a punctuated equilibrium. It attempts to reach a better understanding of the factors underlying success under the current equilibrium conditions. Ignoring system Dynamics and longitudinal developments, the model merely strives to grasp detail complexity. This reduction of real-world complexity allows a high degree of formal theorising with testable hypotheses on cause-effect relationships." (Raisch, 2004, p. 11)

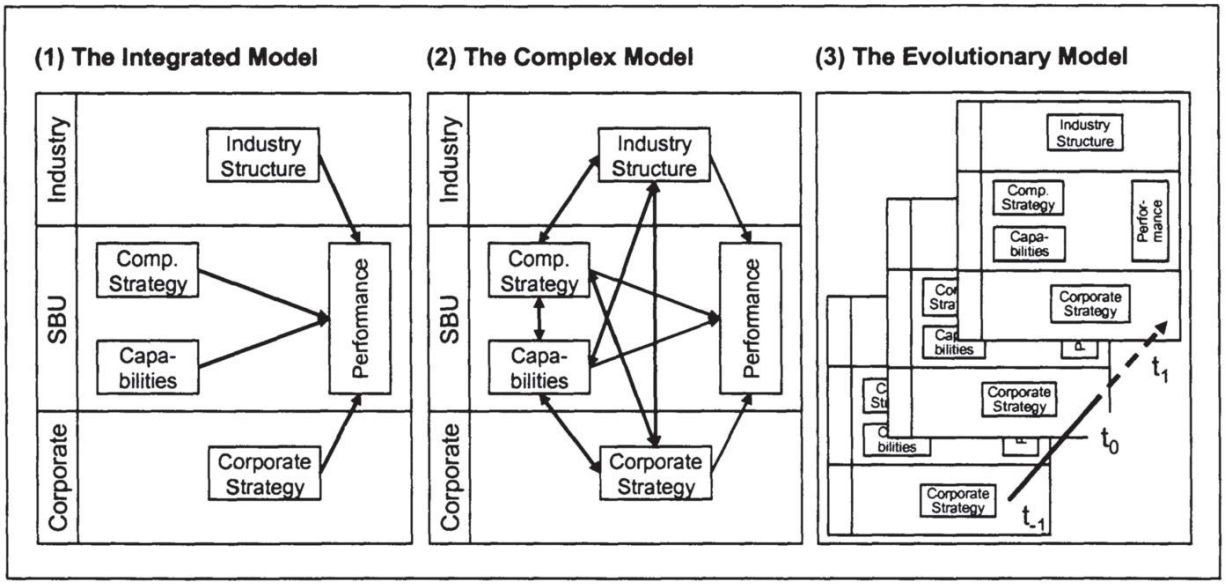


Figure 7: The Dynamic Research Framework (Raisch, 2004, p. 11)

Although Raisch (2004) focuses on firm performance as opposed to service systems, a firm can be conceptualised to a certain degree as a service system, albeit service systems possessing a quality of ubiquity conceptually. A service system can be a microservice in software or a group of organisations in a supply chain (Luzeaux and Ruault, 2010). Thus the Dynamic Research Framework findings are valuable to service systems.

The Dynamic Research Framework arrived at several determinants and conclusions that contribute to the approach of this study. The following determinants were identified: product diversity; vertical integration; balancer strategy; innovativeness; market orientation; organisational learning; reputation and corporate culture. The research made the following conclusions: That there is no

simple success strategy; firm capabilities are highly related to firm performance; differentiation strategy and dynamic capability management plays a vital role in a firms performance; Diversification and vertical integration are to be considered and managed correctly; Attention to the bottom line has to be institutionalised to achieve superior performance; There is no empirical evidence that consolidation, concentration of scope, and scale delivers superior firm performance; to achieve long term performance firms must embrace change and manage it, and the firms structures are to allow this. The determinants identified in the Dynamic Research Framework provide a valuable addition to this research.

2.5 The Viable System Approach Selection Criteria

This research proposes the Viable System Approach (VSA) for diagnosing and designing viable IT service systems. Unlike the other models identified in the literature, the viable system model responds to the first research objective by providing the methods and instruments for quantifying, dynamic complexity and viability. The model's central premise suggests that to achieve viability, the law of requisite variety is to be adhered to. The Law of requisite variety states that: The control achieved by a given sub-system over a given system is limited by (1) The Variety of the regulator and (2) The channel Variety capacity between the regulator and the system (Ashby, 1958; Masys, 2016).

Viable Systems Theory implies the following principles for achieving viability. To maintain viability, there must be a sufficient balance maintained along two dimensions namely: (1) Autonomy of organisational units versus integration of a system as a whole and (2) Stability of operations versus adaption to changing conditions (Ashby, 1958; Beer, 1972, 1985; Masys, 2016). It is for these theoretical foundations that the VSA, and specifically the use of Beer's (1985) VSM, is proposed as a design approach for establishing the desired organisational design for viable IT service systems responding to both objectives of this research. The model posits information that can be used for diagnosis and defines organisational determinants for designing intelligent adaptive systems.

It is important to note the founding concepts of the VSA namely: (1) A viable system lives, it aims to survive within the context of its environment populated by other viable systems and viable meta- systems; (2) A viable system's top management subjectively perceives the context of every system from analysing its environment and contextualizing its ability to meet its own and meta

systems viability objectives; (3) Context defines the potential of viable systems, within which are higher meta-systems able to constrain and govern management decisions; (4) The structural organisation of a system, internally and in relation to other systems higher-order meta-systems define its effectiveness; (5) A viable system has the capability of dynamically adjusting its structure to achieve requisite variety for maintaining homeostasis (Schwaninger, 2009; Golinelli, 2010; Ríos, 2012). It is in these founding concepts that the VSA is selected as a design approach in this research for developing a conceptual model that assist the designing viable IT service systems. The Viable System Model is a model developed by Beer (1985) from applying the VSA to management and design of organisations.

The Viable System Model (VSM) defines and establishes the necessary and sufficient conditions for an organisation, or a service system, to be viable. Viability, as earlier defined by the Oxford English Dictionary (Stevenson, 2007), is the ability to maintain existence in a specified environment. These conditions provide special consideration to dynamic environments. Beer (1985) argues that the primary goal of an organisation is not profits and revenues as many business models suggest, but instead to maintain separate identity and existence within an environment. The VSM was born out of Management Cybernetics in the 1950s (Ríos, 2012, p. 16). It is Wiener who gave the name Cybernetics to the new science and defined it as the science of communication and control in the animal and the machine (Wiener, 1985). In Management Cybernetics the concepts and principles contained in Wiener's Cybernetics, are put into practice by Beer (1972) in tacking management complexities (Harnden and Leonard, 1994). Despite the success of the model in various applications, most professionals are not taught the model and its approaches or how to apply it in practice (Ríos, 2012, p. 8). The lack of adoption could be that its concepts are difficult to articulate into practical implementations. This research uses the VSM model to interrogate and establish the organisational structures required in viable IT service systems.

The VSM defines five essential functions of viability, namely; policy, intelligence, integration, coordination and implementation (Ríos, 2012, p. 50). The viable systems process is a rigorous systematic process that derives the design of the management mechanisms, feedbacks and controls for the five essential functions presented in the VSM. It is founded on careful consideration of the environment in which the system in focus operates. An essential aspect of the VSM is its "recursive" nature meaning every viable system (organisation) contains systems (organisations) that are viable within them as well (Beer, 1985; Ríos, 2012, p. 48). This characteristic provides the

VSM with enormous potential for understanding the design of viable service systems that can recreate viable services within them. It is for this recursive systematic characteristic and its proven success in organisation design that the VSM is selected to establish a model for designing service systems. Whatever the system may be, the same operational principles apply that are required by the VSM, regardless of size, sector, characteristic, geography or type of activity (Beer, 1985; Espejo and Reyes, 2011; Ríos, 2012).

In concluding, the VSM is the model selected for this research to be used to diagnose the viability and provide conceptual designs for viable IT service systems under study. Further details on the VSM and its approach are considered in the next chapter. A review of the selected models in the literature and their limitations lead to the selection of the conceptual model for this research which is elaborated in the next chapter. In researching available models and frameworks, the following criteria were used in qualifying a suitable model namely: (1) the model or framework must have theoretical foundations available in and should have been successfully applied in a similar context in industry. (2) The model or framework should be based on systems-theory based and provide special consideration to systemic pathologies to be avoided (Masys, 2016); and (3) The model or framework should incorporate the design of interactions between highly autonomous entities that synergistically achieve desired emergent qualities given dynamic market environments (Masys, 2016).

The next chapter considers the development of the conceptual model.

3. CONCEPTUAL MODEL

A service system is a combination of people, knowledge, technologies and value propositions (Hastings and Saperstein, 2014; Sushil *et al.*, 2016). Most cited examples of services system are from healthcare, government sectors and financial services (Demirkan *et al.*, 2011b; Hastings and Saperstein, 2014; Roy *et al.*, 2019). In a service system, the consumer of the service and the provider of the service transact in a shared value co-creation network (Hastings and Saperstein, 2014). Therefore service systems are dynamic and present challenges in absorbing and leveraging the input variables of the consumer (Hastings and Saperstein, 2014).

It is important to differentiate between a 'service' and a 'service system'. This is an important consideration from the perspective of complexity because both have to be viable to qualify the system as viable (Beer, 1985; Maglio *et al.*, 2019). A service system is a mechanism and technology through which a service is delivered. Architectural innovation inside the service system allows for the delivery of different services through creative applications of existing technology. On the other hand, a service is a consumable value offering to a market. Delivering a service entails interconnected interaction of systems and sub-systems to deliver a viable consumable value offering to market. Both service and service delivery mechanism constitute a viable service system.

3.1 Conceptualising IT Service Systems

A viable service system can be seen as a system of systems (Luzeaux and Ruault, 2010) because it constitutes a configuration of information, technology, processes, multiple interdepend systems, and end-to-end supply chains for delivering value to an identified market need (Luzeaux and Ruault, 2010; Maglio *et al.*, 2019). Khosrow-Pour (2018) defines a service which is worth noting, namely "Services are cybernetic replicas of human practices, being evoked by well- established environmental motivations." (Khosrow-Pour, 2018, p. 1040)

A system is a set of related or associated material or abstract things, forming a unity or involved whole sharing a common goal (Stevenson, 2007). The Service System Scope of Viability Assessment in Figure 8 is an initial conceptual hierarchical diagram anticipated by the researcher when considering the various operational elements involved in delivering a service to a market.

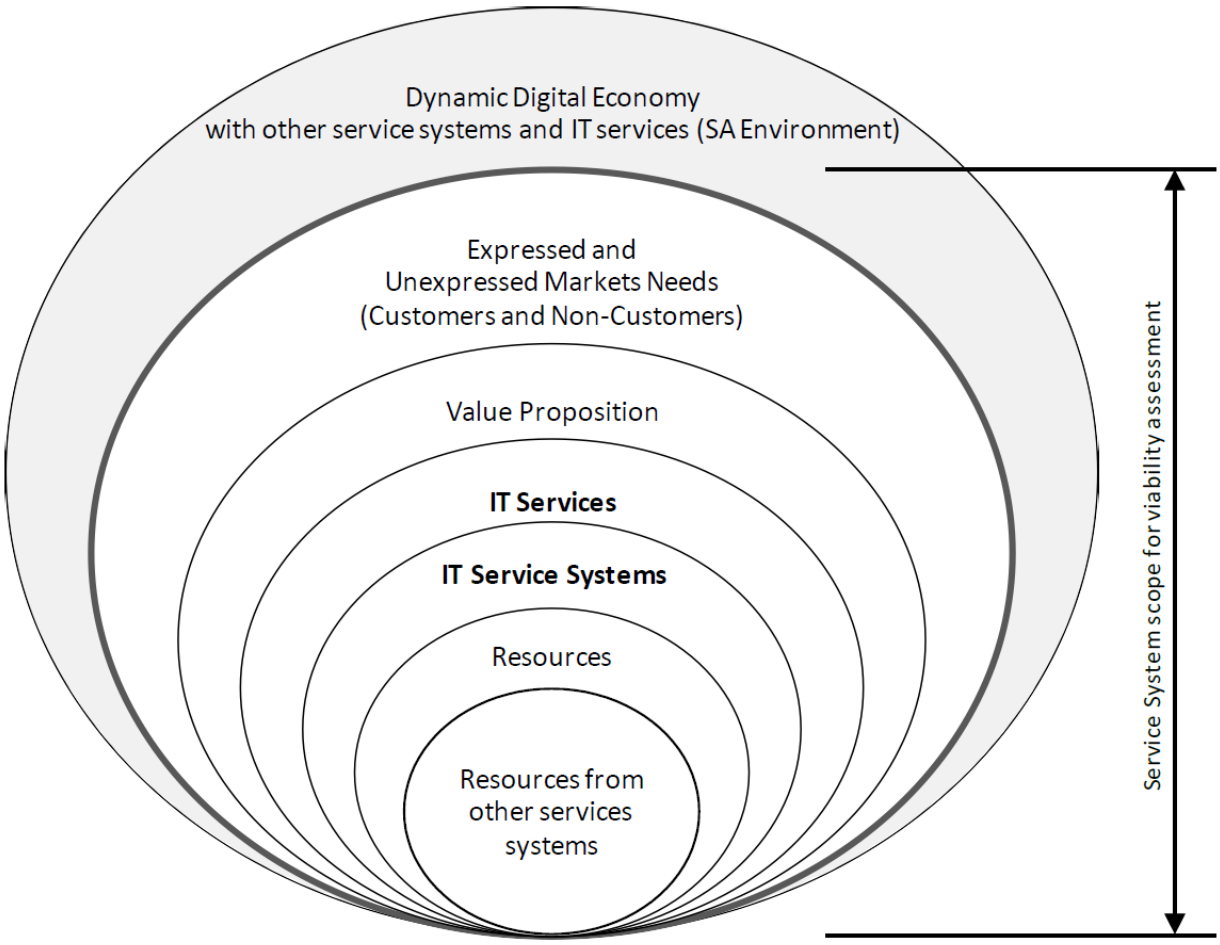


Figure 8: Service System Scope of Viability Assessment (produced by the researcher using soft systems thinking tools)

Therefore, it is in the context of a market that viable service is considered, whereas a service system is viable if it is capable of sustainably delivering viable services, thus able to maintain its existence in a specific environment. In Figure 8, it is envisaged that a service system consists of several systems, including resources from other surrounding service systems, systemically organised to service a market. Without the market need or defined value, a service cannot be viable. Beer (1985) defines viability as the ability to maintain a separate existence within a specified environment.

3.2 The Viable Systems Approach

The viable system model (VSM), Figure 9, has been applied to designing organisations with success and is yet to be applied to diagnosing and designing service systems (Takahara and Mesarovic, 2003). Conceptually a service system shares a resemblance to a specific type of organisation, a Virtual Organization (Maglio *et al.*, 2010; Demirkan *et al.*, 2011a). Similar to a virtual organisation,

a service system is a temporary arrangement of resources within or amongst organisations, working together, delivering services to either organisation-internal customers, organisation-external customers or other service systems or organisations (Demirkan *et al.*, 2011b; Masys, 2016; Hastings and Saperstein, 2014). Therefore, a service system transgresses traditional organisational boundaries because its existence is in the co-creation of value with consumers which could require collaboration between multiple organisations such as in an end-to-end supply chain. The "virtual" in the definition indicates that the resources are not required to interact physically or be in the same geographical or company structure (Camarinha-Matos *et al.*, 2001). The resources are interconnected through networking and collaboration technologies allowing co-ordination of efforts to ends of delivering value (Camarinha-Matos and Afsarmanesh, 2004, p. 17). The temporality in the existence of such an organisation depends on the viability of the service system.

The recursive nature of the VSM can be seen through the VSM diagram model shapes. As seen in Figure 9, the squares represent the management systems; the circles, the operations or implementation system. The amoeboid shape presents the environment in with the system exists. When looking into the circles, the same square-circle configuration can be seen at sub-system levels. This also recurs upwards into higher-level meta-systems. This recursive self-referenced detail in sub-systems reveals the recurring fractal structure required in achieving a viable system. Self-reference and re-creation at all scales, or 'embedments', is required to maintain viability (Beer, 1985; Ríos, 2012, p. 48). Each viable unit is to contain the five essential functions for the system in focus to be viable (Beer, 1985). This excursiveness is of the utmost importance when studying organisations and systems that are to survive in a given dynamic environment (Beer, 1985). An organisational structure is determined by how the system segregates and absorbs the variety from its environment through its autonomous subsystems. Each System and subsystem serves a specific purpose, although containing the same referential fractal structure.

System 1 (Operations) is responsible for the product and delivery of the organisation's goods and services to the appropriate environment. System 1 is made up of viable operational units, each responsible for a line of activity, product or service. The units contained in this system "produce" (Ríos, 2012, p. 25).

System 2 (Coordination) makes the set of organisational units which comprise System 1 function harmoniously. These units may be related by production processes, service delivery or common

resource pools which might lead to counter-intuitiveness sub-optimisation or conflict as a result of each one attempting to achieve its own goals. Examples of System 2s are Information Systems, Product Planning, Accounting Procedures etc. (Ríos, 2012, pp. 29–30).

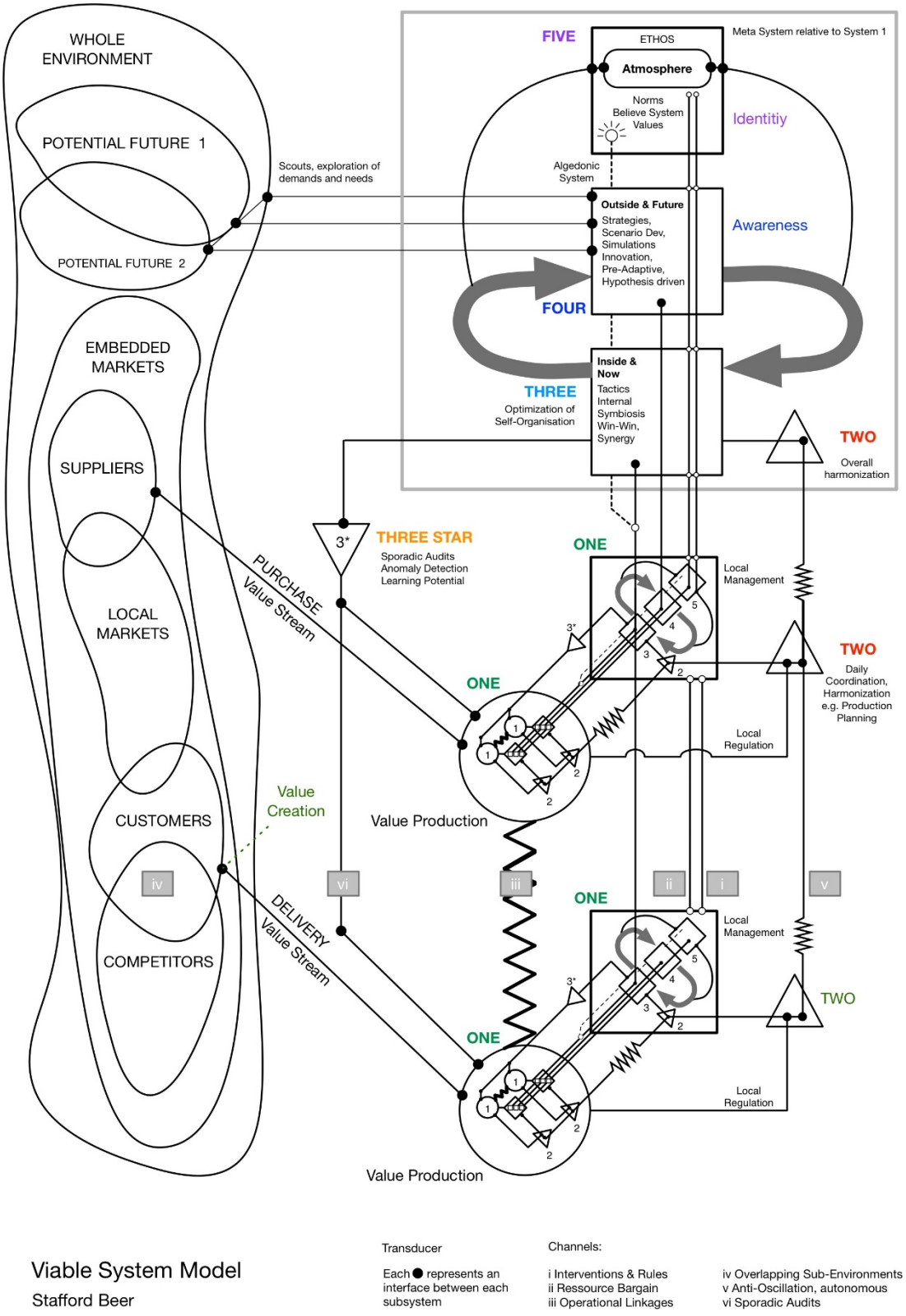


Figure 9: The Viable System Model Example (Beer, 1985).

System 3 (Integration) performs a harmonisation role exploiting possible synergies form the interactions of System 1 subsystems. System 3 may be considered the "Operational Management" of the organisation. This system is concerned with the daily operations. It is concerned with the organisation "here" and "now" (Ríos, 2012, p. 32).

System 4 (Intelligence) represents the organisation's adaption structure. To do this, the organisation must monitor both what is currently occurring and possible future changes subject to the appropriate environment. This system contains the right tools and methods to process and analyse information, variety and complexity presented by the organisation and its environment. The translation from data to information, to modelling and intelligence, is performed here (Ríos, 2012, p. 40).

System 5 (Policy) has supreme authority in the organisation. All variety that all the other subordinate functions cannot absorb is resolved by System 5. System 5's function is to balance the present and the future of the organisation, or 'the bigger system in focus'. It is responsible for establishing the identity and purpose of the organisation. Typical responsibilities of system 5 are establishing the vision, mission and strategic goals of the organisation (Ríos, 2012, p. 46).

Determining the viability of a service system will provide a base from which crucial determinates can be defined, designed, managed and re-created. The application of the VSM to service systems is novel, but other previous applications of the model reveal the following two critical findings. In redesigning systems for viability, various tools are used in the VSA. The VSM Charts and Homeostatic Loop Analysis Charts are used to determine the service system structures required to maintain viability.

The VSM model approaches complexity from a structure-design shown in the Framework for Designing Intelligent Organizations (FDIO), Figure 10. In practical application, the VSM is used with other cybernetics models in the designing process of a viable system. In the FDIO, the VSM performs the role of defining the system structures and mechanisms required for maintaining viability. The structural design approach to complexity management makes the VSM model suitable as a meta-model in developing a systemic framework within which the other models are plugged into.

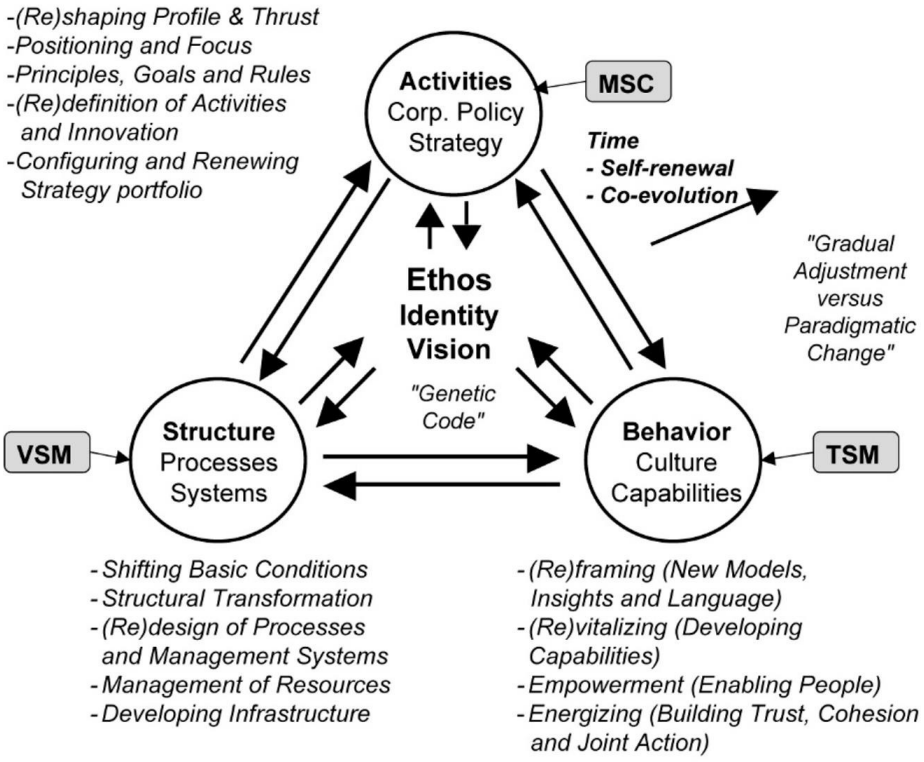


Figure 10: Cybernetics Models linked to the Framework for Designing Intelligent Organizations (Schwaninger, 2009)

The Model of Systemic Control (MSC) is integrated into the VSM approach to defining the system control requirements for maintaining homeostasis and control in the system to manage system viability (Beer, 1966). On the other hand, the Team Syntegrity Model (TSM) defines the networked linkages required to foster collaboration and development in the design activities, management and implementation activities. The linkages between these models can be seen in Table 2 and Table 3, demonstrating how they are applied in the FDIO (Schwaninger, 2009).

Table 2: Linking the Cybernetics Models to their Dimensions (Schwaninger, 2009)

	Design	Control	Development	
Activities	x	xx	x	MSC
Structure	xx	x	x	VSM
Behavior	x	x	xx	TSM

The scheme in Table 2 highlights two aspects. First, each of the three framework dimensions, namely activities, structure and behaviour, contribute to an aspect of management, namely design, control and development, denoted by x. Second, each of the three models has a primordial link to one of the framework dimensions, denoted by 'xx' (Schwaninger, 2009, p. 44).

Table 3: Correspondence between Dimensions and Linkages with Cybernetics Models (Schwaninger, 2009)

Design	<--->	Structure	<--->	VSM
Control	<--->	Activities	<--->	MSC
Development	<--->	Behavior	<--->	TSM

Each model places a different emphasis on the three components of management. The VSM is a conceptual tool for organisational design. The MSC is for organisational control and the TSM if for organisational development. Linking the scheme in Table 2 to the emphasis points of each model, a correspondence is derived, producing the scheme in Table 3 (Schwaninger, 2009, p. 44).

In the Brain of the Firm, Beer (1972) uses Dynamo, a system dynamics (SD) modelling software to investigate the dynamics of the trapped states within which the Chilean economy was enmeshed. This research will use Goldsim, a system dynamics modelling software with probabilistic simulation capabilities, to model the service system dynamics within a dynamic market with the assistance of the SD model archetypes provided by Akkermans (Kossik, 2018; Akkermans, 2018). The conceptual system dynamics model is used to define the relevant determinants to designing viable IT services and to prescribe policies that mediate between the current systems' performance of VSM (Systems 3-2-1) (Beer, 1966), the current structural situation and the formulation of strategy (Beer, 1972; Akkermans, 2018). Intelligence and decision science is the primary function of System 4 (Beer, 1966). It is to utilise models and intelligence to mediate between System 3 and System 5 as prescribed in (Beer, 1966).

This research will contribute by reporting findings on the application of the Viable Systems Approach, while also incorporating other cybernetics models, in the context of designing service systems in the South African IT industry. This approach is posited to ensure that the IT service systems designed are viable, meaning they are to be: self-referencing to maintain identity, self-aware, self-repairing and self-reproducing with the ability to intelligently maintain system internal homeostasis from external environment by either internally restructuring or leveraging other service systems in its environment (Beer, 1972; Harnden and Leonard, 1994; Schwaninger, 2009; Ríos, 2012).

Having posited that the VSM is a suitable model for diagnosing and redesigning viable IT service

systems along with the use of other cybernetic models, the next section provides the conceptual model developed by the researcher for designing viable IT service systems considering dynamic market environments, competing and synergistic service systems.

3.2.1 Proposed Conceptual Model – The Integrated Service System Model

The Integrated Service System Model (ISSM), as the name suggests, integrates the VSM, TSM and MSC into a hierarchical embedment, previously defined in the service system scope of viability in Figure 8, reproduced below in Figure 11.

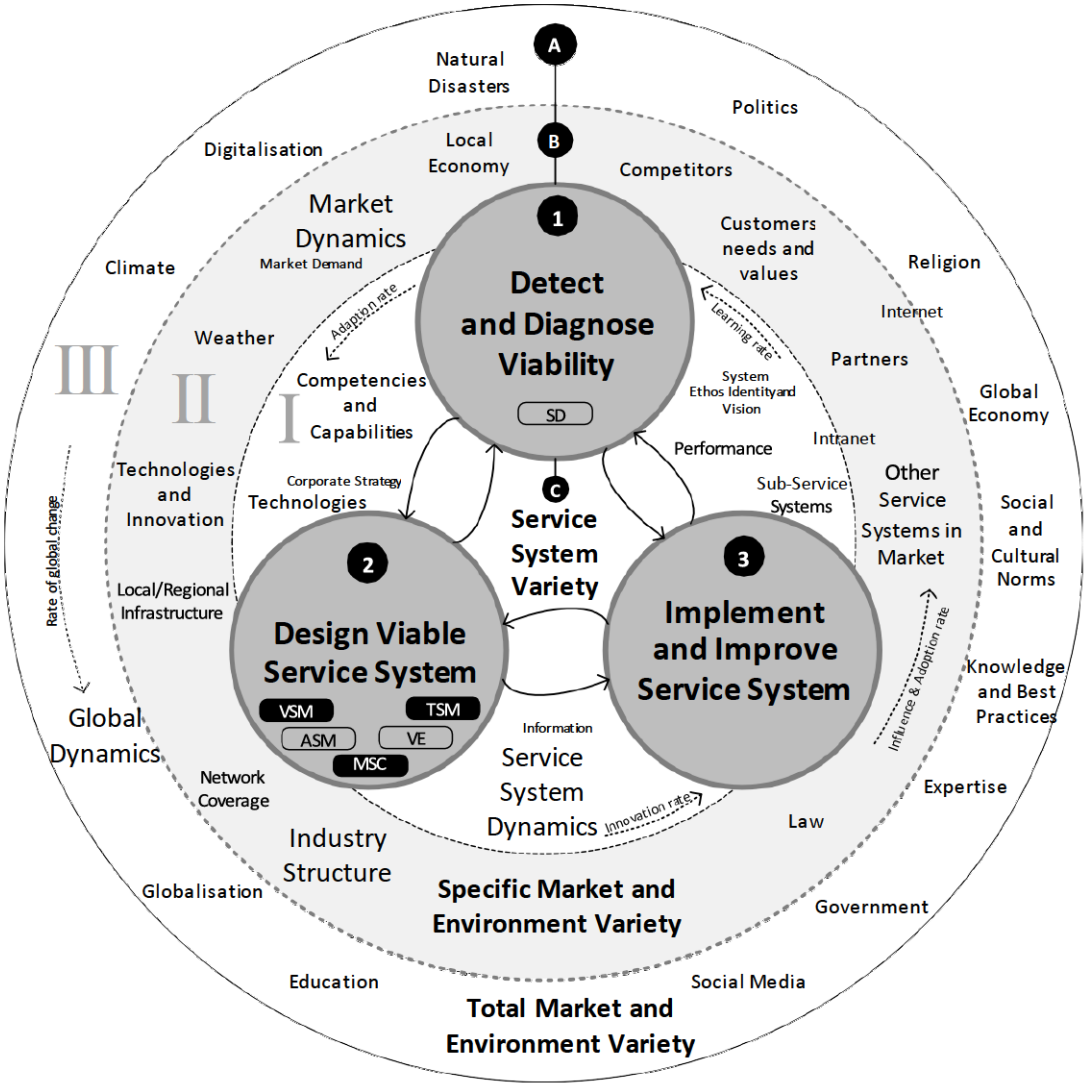


Figure 11: The Integrated Service System Model (ISSM)

The model is developed with the objective of providing a service system design which can adapt to relevant market dynamics through a mechanism of continuous variety engineering and an the integrated iterative use of other cybernetics models, namely the Team Syntegrity Model (TSM) and

the Model of Systemic Control (MSC), and uses other cybernetic modelling tools namely, the Abstract State Machine (ASM), System Dynamics (SD) and Variety Engineering (VE).

The model defines three primary functions that are to be present in a viable system, namely; Detect, Design and Implement.

The three functions with feedback mechanisms between them establish double-loop learning required for intelligent adaption (Sterman, 2000, p. 19). Feedback from the environment can stimulate redefining service system viability in the context of the dynamic environment. Such learning involves reframing of a situation to new goals and new decision rules and not just new decisions.

The next sections discuss the conceptual model components in detail.

3.2.2 Detect and Diagnose

The Detect and Diagnose function is responsible for ensuring that the service system is capable of detecting changes inside and outside the service system and contextualise its viability within its dynamics environment. Having contextualised viability, the function diagnoses whether residual variety existing internally within the service system. The ability of the service system to adapt is dependent on its ability to detect and contextualise all the market and global dynamics in all their variety and produce a diagnosis of viability. The implication is that within the detect function is the ability to interpret dynamic complexity (Sterman, 2000, pp. 21–23) into an actionable diagnosis. The function detects across the spectrum of variety from Global Markets, A, to the local market environment, B, to internal service system dynamics, C. The underlying principle is that all three detection points are required to maintain service system viability for both current and future markets (Beer, 1985). Globalisation and digitalisation, in the outer circle, along with other global factors, introduce change into the global economy, this is visualised as a rotating outer wheel, with its rate of change represented by the rotational speed of the outer wheel.

This rate of change of the outer wheel, III, through forces of adoption and influence, in turn, rotate the next internal wheel, II, at a specific rate. The difference in rotational speeds between the circles is resistance to change, the difficulty of adoption or merely a delay to adoption. The systems I II and III seek to minimise friction. What is important to note is that ‘friction’ is a feedback mechanism

influencing the rotational speed of both III and II, and subsequently II and I. The other wheel does not rotate at an ungovernable speed, there is feedback which can slow down all the wheels to a stable system maintaining requisite variety and homeostasis. The entire system wants to maintain homeostasis (Beer, 1985); visually, this is the wheels rotating at the same rate. This complexity absorption inertia is best illustrated through innovative start-ups that crash even though having all the noble creative ideas. In such a situation, System I rotated faster than II, which creates friction, or residual complexity beyond the viability threshold required for the existence of the system.

The wheels, I II and III, do not necessarily always have to be rotating at the same speed as a principle, but there exists thresholds of friction that could render the entire system, or sub-systems, inviable. The idea of the models is to demonstrate the existence of global market dynamics, III, that 'turns' local market dynamics, II, which 'turns' the services system innovation. The 'turning' could also be initiated by the service system I to influence market dynamics. There is also feedback between I and II. The model seeks to represent relevance as dynamic and influenced by external forces beyond the current immediate market and also influenced by the service system itself, this is also a good conceptual starting point in defining a viable triple embedment of the viable system. The innovation of a service system could, in turn, create its demise in future by not being able to keep up with the 'rotational momentum' it created.

The most inner circle represents the service system in focus, in this case, an IT service system. The IT service system has to adapt to maintain relevance with the market it serves. This segregation, A B and C, does not represent physical or value boundaries but is a proposed concept to the extent to which the service system needs to detect a change to maintain sustainable viability. The Detect function makes use of system dynamics (SD) models and real-time market information to articulate trends and dynamics for translation into a residual variety. The detected residual variety initialises the Design function or informs the Implement function depending on the 'detect-response' policies in place. The Detection function has feedback from both the Design and the Implement function to ensure that the function is relevantly refined and improved through change. In the next section, the Design function is discussed.

3.2.3 Design Viable Service Systems

The objective of the Design Viable Service Systems function is to provide viable service system designs looking at policies, structure, behaviour, technologies and other existing service systems.

The design function can be initiated by both the Detect function and the Implementation function. This control is to ensure that viability is maintained through implementation changes and that there is continuous validation feedback during implementation to redesign service system designs. Failing to incorporate variety introduced through implementing change can also lead to un-managed complexity. Establishing feedback mechanisms allows for managing change in such a way that viability is not only achieved but maintained throughout the implementation of changes.

The Design function makes use of the TSM, VSM, MSC, VE and ASM to produce viable service system model designs. The TSM is used to establish the networking structures that foster collaborative, creativity knowledge creation and a culture of empowerment. The VSM prescribes the required organisational structures to achieve viability in a system. VE and ASM are used in the design process to analyse and assess complexity. The MSC defines and models, with the assistance of SD modelling, the decision policies and controls the activities through feedback control mechanisms.

3.2.4 Implement and Improve

The Implement and Improve function is responsible for implementing the viable system designs from the Design function and systemic improvement as well. The implement is to ensure the designs are implemented as informed by the urgency or priority evoked by Detect.
Detect not only detects residual variety but translates it to prioritised action to either redesign or execute responses through systems that are implemented. Unresponsiveness from the implement function may initiate a redesign. This control caters for the situation where the transformation project underway is too slow to respond to market changes. Viability has to be re-assessed and initiate new system redesigns. In cases where implementation is irresponsive, the Design function could source resources from other service systems while maintaining service system identity.

3.2.5 Adapt, Innovate and Learn

The model also identifies three rates that determine the ability of the service system to maintain viability, namely; adaption rate, innovation rate and learning rate. The adaption rate is the service system's ability to convert the specified residual variety from Detect to viable system model designs. The innovation rate is the speed and efficiency at which the developed viable system model designs are implemented. The learning rate is the ability of the service system to translate

implemented changes in the service system into new knowledge and insights to refine viability definition. The researcher proposes that the three functions, with the feedback loops between them and conversion rates, are fundamental not only for establishing viable IT service systems but also for maintaining viability sustainably.

The ISSM attempts to incorporate the valuable findings from researched models and frameworks into a unified, integrated systemic model for designing viable IT service systems. This model is proposed as a model to design viable IT service system models that not only establish viability by continuously adapt through a mechanism of Variety Engineering and homeostasis but also maintain viability as the service system adapts to its dynamic market environment. The model makes use of cybernetics models to contextualise and analyse viability for a service system, and redesigns/re-engineers the service system to a state of sustained viability. The next chapters discuss the research methodology applied for testing the application validity and reliability of the ISSM.

4. RESEARCH DESIGN AND METHODOLOGY

4.1 Research Methodology

Following this study's objectives, both qualitative and quantitative techniques are applied depending on the objective in question, although a qualitative research approach is predominant. As required in the first research objective, the research focuses on IT service systems structure and the impact thereof on their ability to absorb complexities in their environments. To address this a qualitative research approach is selected in investigating this phenomenon on IT service systems in their natural setting with non-mathematical data analysis process. Qualitative methods are valuable for investigating and exploring dynamic, embedded phenomena which cannot be adequately captured by quantitative techniques such as in complex organisational behaviours and structures (Cassel *et al.*, 2018). Qualitative methods are utilised in identifying, classifying, diagnosing and validating residual variety as prescribed by the viable systems approach. In this study, the researcher selects qualitative research methods of inquiry for the first objective in the research as they are especially suitable for investigating phenomena and exploring theory, frameworks, models and development opportunities (Cassel *et al.*, 2018, p. 19).

Although the approach of inquiry is predominantly qualitative, quantitative methods are more suitable for analysing business reports and developing systems dynamics models and quantifying residual variety in line with the second research objective. The focus of this research for the second objective of the research will not be on the qualitative analysis of the models prescribed, but rather in using the model results in accurately defining determinants and design elements constituting a viable IT service system design. The required quantitative data is summarised to present qualitative characteristics of the IT services system and validated through focused interviews and interdisciplinary workshops (Creswell, 2009; Jabareen, 2009; Flick, 2014; Patton, 2015). Qualitative methods are then used to quantify variety for Variety Engineering Analysis and in statistically summarising the data input into the developed System Dynamics model.

In this study, multi-disciplinary workshops and focused interviews are recommended by Beer (1966) for the practical application of operational research (Harnden and Leonard, 1994) when applying the viable systems approach. System states, perturbations, capabilities and constraints are allocated to classifications using indexing in a versatile mind mapping tool, Mindjet MindManager 2019. Some quantitative analysis is then done in Microsoft Excel to statistically summarise

retrieved data from the support systems and business reports. Having collected all the information and data from the workshops and focused interviews, the proposed ISSM is then used as a conceptual model for determining key determinants in designing viable service systems.

4.2 Process of the Research

The process of the research involves the use of data gathering from various systems, individuals and teams regarding their processes, procedures and performance. Figure 12 presents the research logic that is applied.

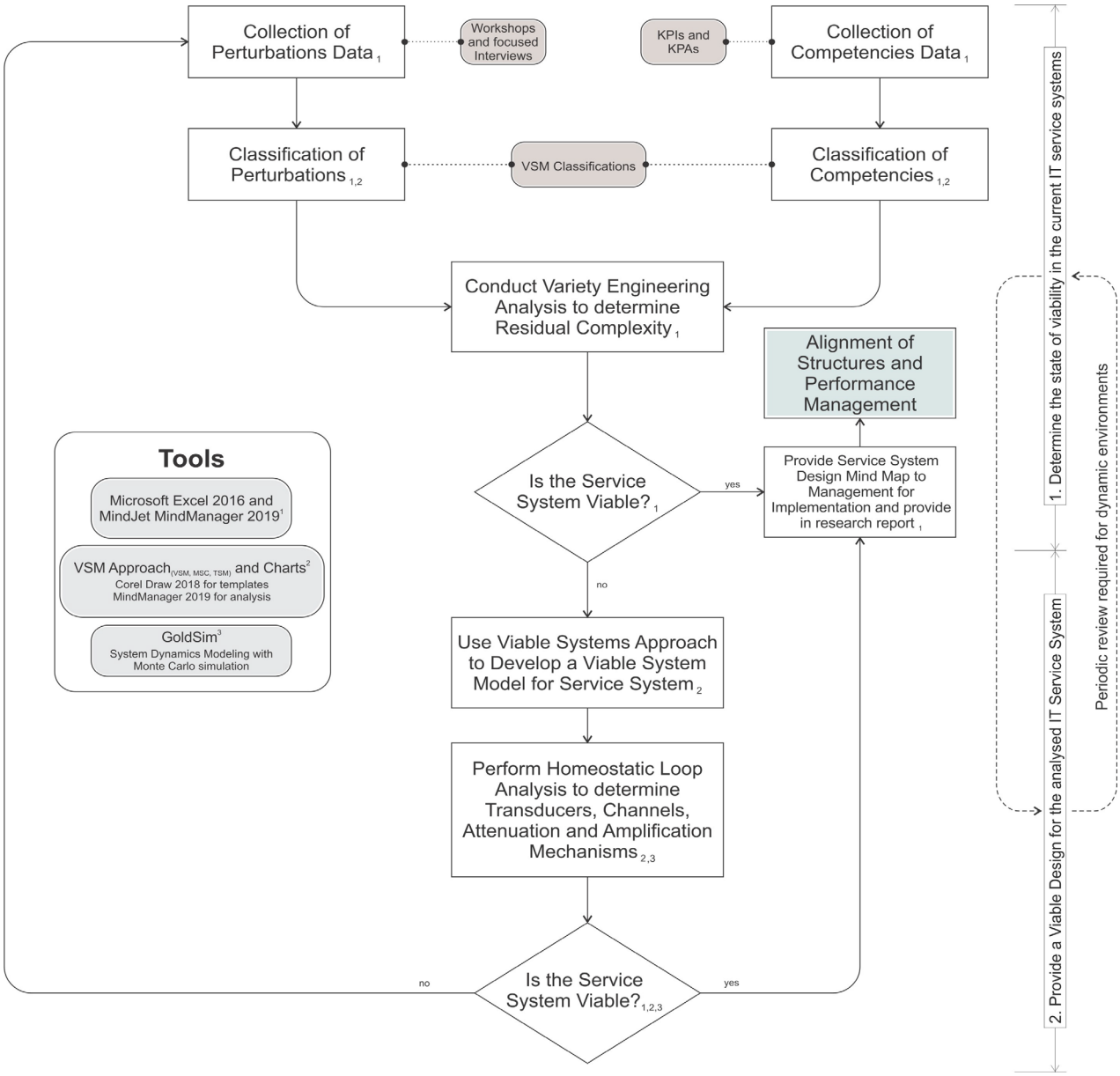


Figure 12: Research Project Logic Flow and Tools

Due to the diagnostic approach of the research process, the research project investigates the Cloud offerings already existing in the company for over two years for the following reasons, the service

is to have enough historical data, expertise and knowledge within the organisation regarding the delivery of the service, and in the timing of this research project, the cloud business was of significant priority to the company.

4.3 Determining the state of viability in current IT service systems in South Africa

The first objective of the research process is to diagnose the viability state of current IT services systems in the industry. Initial diagnosing the state of viability is to ensure early selection of cases in which redesign is necessary. The VSA approaches system design from a complexity diagnosis perspective interrogating organisation viability definition and structure. This is done by assessing whether the variety presented by the environment within which the system of interests operates and the variety absorbed and presented by the system operations, is absorbed entirely by its management systems (Espejo and Reyes, 2011, p. 52). A diagrammatic presentation is in Figure 13. This process is called Variety Engineering (VE). Ashby's law of requisite variety prescribes that the complexities of the managed system and the managing system are to balance to achieve viability system design (Ashby, 1958).

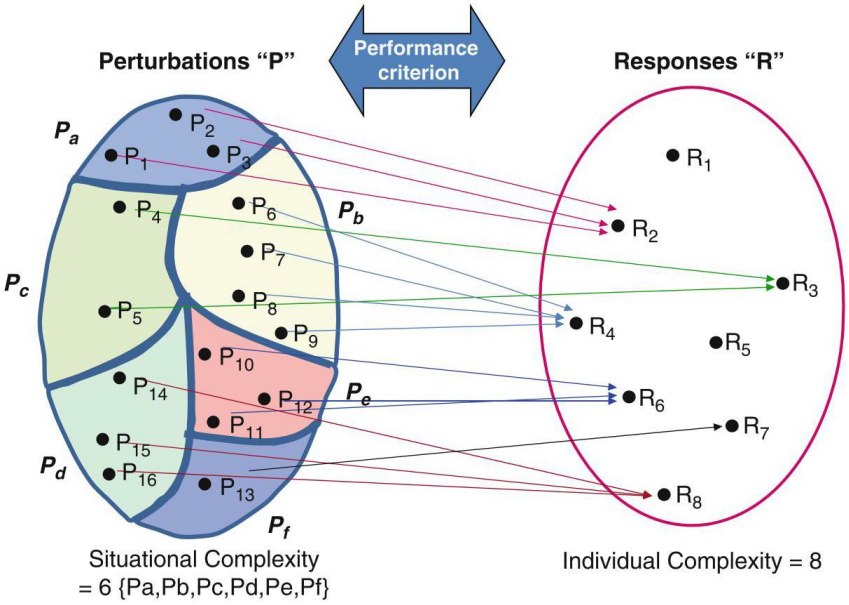


Figure 13: Managing the Complexity of a Situation (Espejo and Reyes, 2011, p. 52)

An imbalance in complexities, specifically in the case of a higher complexity presented by the managed system, means the managing system is incapable of controlling the system under management (Ashby, 1958; Espejo and Reyes, 2011). Complexity in the context of the law of requisite variety is scientifically quantified as Variety. Variety is the number of possible states of a system (Ashby, 1958; Beer, 1985)."When observing a system from the outside, we may compute its variety as the number of possible states of the black box we use to describe it. Its complexity, on the

other hand, is the number of outcomes (dynamic states), that we can distinguish over time." (Espejo and Reyes, 2011, p. 40)

The 'black box' in the statement by Espejo and Reyes (2011) above is a conceptualisation of any system as an abstract state machine. This method is an effective method for determining the viability of a system by calculating system complexities, what Ashby (1958) refers to as varieties. Complexity is how much of the system variety is exposed over time (Ashby, 1958). Initially in defining the 'black box', it is to be assumed that all the system variety is exposable and identifiable (Ashby, 1958; Beer, 1972, 1985; Boeger and Stark, 2003). To perform this analysis initially, two sets of data are required; the perturbation or disturbances, which increase variety; and responses or capabilities, which absorb, attenuate and amplify variety.

4.3.1 Sample of Participants

The participants in this study are selected from the VAD and six strategic partners who possess strategic knowledge, management knowledge and technical knowledge on the service systems under consideration. The selection criteria were based on ensuring that multidisciplinary perspectives are considered during service system design. The participants include four company executives, eight senior management, four business unit managers, four service delivery managers, six departmental managers: financial manager, marketing manager, compliance manager, operations manager, IT support manager, business intelligence manager. Participants also included service engineers, pre-sales engineers, support desk staff and selected strategic partners comprised of companies that transact with the VAD; these were six companies in total. There was thirty-one participant in total in the study. In the workshop sessions participant were grouped into teams of five and six while ensuring comprehensive coverage of multi-functional contributions per team. Two, work week-long, workshop sessions were conducted. The sessions totalled ten days. The workshops covered all service system design and management of all IT services currently provided by the VAD.

4.3.2 Data collection for Perturbations and Capabilities

The data sources for this research are from within a leading VAD in the South African IT industry. The VAD is a pivotal source of data and information because VADs play a critical role in providing, managing and aggregating IT services to a reseller community in South Africa. This

provides both breadth and depth of knowledge across multiple IT service systems in South Africa. Three years' worth of data is collected and presented in a statistically summarised for confidentiality. The information is presented in a mind map. Discretion is exercised on the level of detail on data provided.

Interviews with the VAD service engineers are used where information is not attainable from business systems. Initially, the information required is the various perturbations that exist from providing IT services in South Africa. The objective is to capture the unique types of perturbations (Espejo and Reyes, 2011, p. 52). The number of occurrences at this stage is of little relevance but are considered when further analysing the residual variety in system re-design. In the system redesign stage, quantitative methods such as system dynamics modelling, are used to model the complexity presented by the residual variety and the likelihood of their occurrence. Perturbation data are collected from support ticket systems, development team reports and market performance analysis. Structured Query Language (SQL) is used to query the IT service support system and the digital platforms to attain all the support ticket information and market performance information. The data are verified with ticket requester to confirm that the support request was captured correctly.

The collected perturbation data and information are statistically summarized in a way that protects company information and then inputted into Mindjet MindManager 2019 for qualitative analysis, as demonstrated in Figure 14. MindManager is a mind mapping software with the capability to index items, apply smart filtering, edit topics to defined sets of rules, perform calculations and allocate items to classifications, topics and categories amongst its project management capabilities (Mindjet, 2019). MindManager was selected over other tools, such as Microsoft Excel, because of its ease of use and flexibility which allows for the effective capturing and categorisation of ideas and discussion topics. Nevertheless, Excel was used to analyse the support ticket data and to provide summary statistics.

Capability information is obtained through focused interviews with management staff in charge of the service systems and the performance management systems that are in place. In addition, employed skills and expertise also form part of the service system capabilities information. Capabilities are allocated into classifications on the VSM Model. The importance of key performance indicators (KPIs) when defining service system capabilities is based on the principle that 'you can only manage what you measure' (Ashby, 1958). Capabilities cannot be defined as a

capability unless there is a KPI in place that measures it. A perturbation is not detectible if there is no KPI in place to detect it. Where a perturbation critically impacts a critical success factor, then the system presents residual variety. The collected capability data and information is equivalently summarised in a way that protects company information and then inputted into Mindjet MindManager 2019 for qualitative analysis.

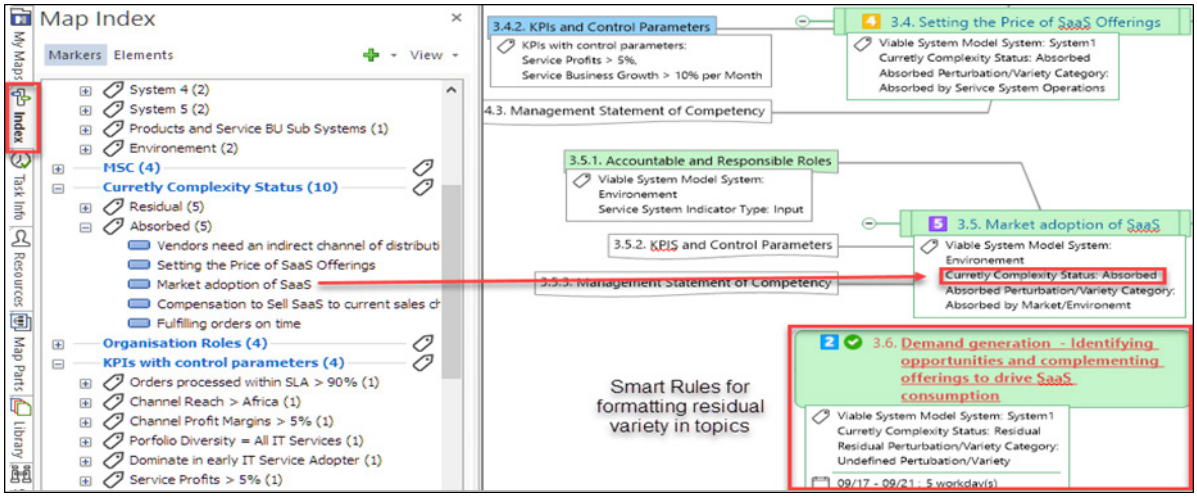


Figure 14: MindManager 2019 use of Indexes and Smart Rules for Qualitative Data Analysis

4.3.3 Qualitative Data Analysis

Once the perturbations are collected they are grouped into classifications of root cause analysis categories and the service system configurations they originated from. The first categorisation is the service configuration from which they originate. The perturbation root cause is the second categorisation. This is important because only taking the face information from the support case assumes that the requester understands the problem. Root cause analysis is conducted ensuring accurate allocation of perturbation into the exact root cause. This is to ensure that classifications are created whenever a new type of perturbation root cause is identified. All perturbations gathered from the various systems and interviews are to belong to a classification accurately representing the complexity and nature of the perturbation.

A MindManager mind map, example in Appendix D – Mindjet MindManager Map with Classifications and Indexes, is used to list all the perturbations identified and their classifications. Thirdly, the perturbations are analysed on whether a capability exists in the service system for a response or not. Perturbation-response analysis is done through the use of indices in the MindManager tool. The perturbations that are left unallocated tackled by providing a conceptual viable service system design for their service systems. When these unallocated perturbations

critically affect the performance of the service system, they represent residual variety as presented in Figure 15, which is dealt with in detail in section 6.3 (Espejo and Reyes, 2011, p. 69).

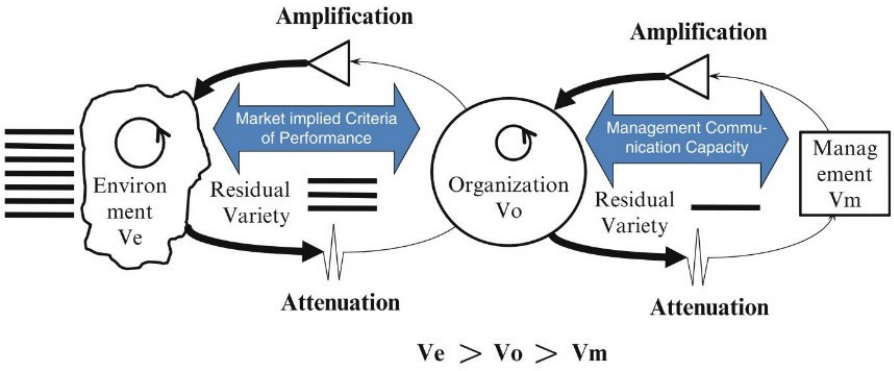


Figure 15: Residual Variety in an Organisational Context (Espejo and Reyes, 2011, p. 69)

4.4 Validity and Reliability of Measurement

The data collected in this research assumes that the data supplied by sources are accurately captured. It is difficult to verify the accuracy of data for every service. Where information seems unclear or incomplete, interviews are conducted for clarification and verifying what is understood from the data. This helps improve the validity of the data collected. It can also be appreciated that the person interviewed might not want to share specific sensitive information. In such cases, they are informed that summary data is used. The research assumes that this information is accurate and valid where details cannot be divulged.

An example of summary data requirements needed to analyse complexity is provided in the study of the criminal court system in Bogota, Columbia (Espejo and Reyes, 2011, pp. 53–54). This example demonstrates a sufficient level of information required to perform viability engineering and complexity management can be attained even where the details on the instruments used to attain the information are not provided. It is therefore assumed, due to the mitigated sensitivity of the information provided, that this information can be solicited from departmental managers who are willing to share the information.

This research uses focused interviews and multidisciplinary team workshops with service engineers, staff and management to attain information that would otherwise be limited, unreliable, restricted or inaccessible. Focused interviews and workshops provide high validity because participants can discuss issues at depth and interrogate assumptions and information from systems. In the interviews and workshops, the researcher's role is to facilitate proceedings and to pay careful attention in

providing open-ended questions for discussion that do not lead to a premature solution while maintaining neutrality in probing for more information on topics discussed (Patton, 2015). The research in this study attempted to maintain neutrality by providing open-ended questions, such as "are there challenges that you are facing in delivering your services?", for focused interviews and workshop, and the researcher fulfilled the role of teaching the techniques and tools as a facilitator in the workshops.

In the literature review, it is noted that the viable system model concepts might be difficult to grasp, training is provided to the participants to effectively use the cybernetics concepts to define and analyse current service systems from a complexity management perspective. A high-level one-day introduction and training session is conducted in the kick-off workshop. The introductory training session provides participants with basic training on systems theory, the VSM, MSC and TSM, the principles, cybernetic concepts and techniques. Exercise examples of translating systems into states using simple systems, such as a watch, are also provided for practising the application of the techniques.

Although challenges are presented regarding repeatability and reliability because participant contributions are unpredictable, focused interviews and workshops yield in-depth responses about experiences and knowledge that is unattainable from information systems alone. To achieve integrity and validity on qualitative data collected, the researcher utilises qualitative research guidelines provided by Patton (2015) in designing the open-ended questions such that participants are allowed to respond in a way represents their viewpoint while using probing questions to gather more information on feedback provided. This research will also make use of field observations, mind map visual models and simulation models to understand further the complexities in the topics discussed.

While this approach to data and information collection poses clear limitations regarding the reliability of data, several assumptions were made to assist the study. These are further discussed in the subsections below.

4.4.1 Validity and Reliability of Perturbation Measurement

Perturbation information lives in support case or ticket systems, customer feedback databases and market performance information. Once collected, the perturbations are identified and are allocated

to six categories in workshop sessions. Perturbations can be identified in support ticket systems as open tickets that remain unresolved, resolved tickets transgressing service level agreements, the customer expressed frustrations that do not have a KPI for measurement and customer expected capability lacking in the service system. Other perturbations remain undetected until reflected through customer loss. Therefore, sales information is also studied. All the noted perturbations may impact severely on the IT service system viability. Classifications must capture all perturbations that can exist in an IT service system under study.

Perturbations will fall into the following six categories: (1) Market/Environment absorbed. These are known perturbations that are not absorbed by the organisation but instead left to be absorbed by the market or environment. (2) Absorbed by another service system in the ecosystem. These are known perturbations that are allocated to another system service system to manage with monitored KPIs and Service Level Agreements in place. (3) Absorbed by Service System Operations. These are perturbations absorbed through operational technologies, sub-systems, processes and people in the organisation. (4) Absorbed by Service System Management**.** These are known residual perturbations that cannot be absorbed by the environment or the operational system for practical or financial feasibility reasons. Decision policies are in place to manage or mitigate the risk of such cases individually as they arise.

The perturbation is expected, and the risk is defined and measurable but does not justify dissolving the service. Service System Management absorbs the residual variety here. (5) Known Residual currently under consideration for design. These are known residual perturbations with projects in progress to absorbing such perturbations. The implementation can be either through other service systems or in operations, and (6) Unknown Residual requiring further research or root cause analysis. These are perturbations picked up through analysing market performance, customer retention rates and revenues. These present a discrepancy to expected forecasts and plans. These would still not be defined as yet but are detectable.

Once residuals are collected and categorised in MindManager a cross-functional team of company management is asked to validate the perturbations. They do a root-cause analysis of the perturbations using Ishikawa Charts and other soft systems thinking rich picture tools.

4.4.2 Validity and Reliability of Capability Measurement

Archetypes are reusable representations of the best way to model commonly found cases or challenges in various industries (Sterman, 2000; Akkermans, 2018). Some system dynamics (SD) archetypes are presented by Akkermans (2018) and Sterman (2000). One model that is of high relevance for this research is the 'generic service system', as seen in Figure 16 provided by Akkermans (2018). Utilising tools such as mind maps and SD models helps in the facilitation of a collaborative process for delivering an accurate and reliable definition of organisational capabilities (Meyers, 2009, pp. 665–688). An interdisciplinary team of business unit managers, presales engineers, support and operations, are invited to the service system capabilities workshop discussions. A high-level system dynamics CLD of the service system SD model built is provided to validate assumptions underlying the definition of capabilities and the feedback loops involved.

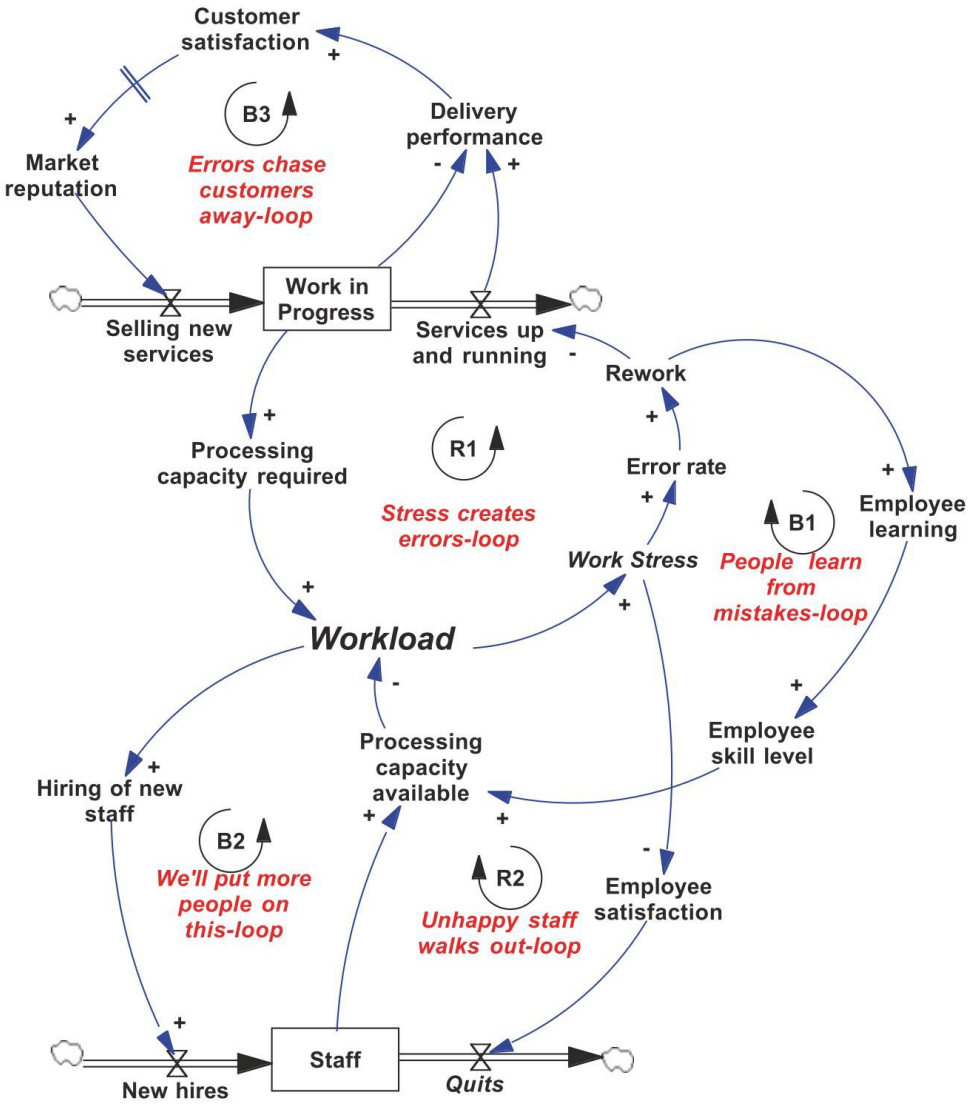


Figure 16: The Generic Service System SD Model (Akkermans, 2018)

The researcher's role is to teach the tools to selected teams; collect and consolidate all relevant documented procedures and KPIs in the organisations, facilitate the workshops and develop the models that present the dynamic systemic behaviour capturing the assumptions made during the sessions. The researcher is responsible for developing system dynamics causal loop diagrams (CLDs), developing systems dynamics models, producing functional behavioural decomposition models, the collection of the data and information required to build these models and the verification and validation of these models with relevant departments within the businesses.

These activities help in improving the validity and reliability of data collected by utilising visual modelling tools that ensure consensus, understanding and interrogation of assumptions while accommodating for multidisciplinary perspectives.

4.4.3 Collection of Perturbation and Capability Date Challenges and Considerations

Diagnosing a requisite variety of an operational service system begins with juxtaposing the capabilities that are required to provide the services against the perturbations that are presented in its operational environment (Espejo and Reyes, 2011, p. 52; Beer, 1972; Ashby, 1958; Beer, 1966). This is called Variety Engineering (VE). VE diagnosis is conducted first because the service system could be viable. Conducting the diagnosis first ensures that service system redesigns are not prematurely done unless the residual variety is detected (Espejo and Reyes, 2011). It is important to note that capabilities and perturbations are kept to date in dynamic environments to ensure the service system maintains relevant to the market (Schwaninger, 2009).

The challenge in maintaining consistent data regarding all capability and perturbation data is that every individual within the organisation has differing views, interpretation and understanding of the service systems' viability. A collections method used in this study had to overcome the following challenges: Perspectives differ regarding the performance of a service system, therefore the capabilities required and measurement of capability are different depending on who is being interviewed; Defining the capabilities or perturbations of a service system requires a multidisciplinary approach and involves multiple perspectives; Although capabilities are quantifiable, i.e. revenues, perturbations presented by a dynamic industry and market are not easily quantifiable due to lack of data or non-quantifiable contributors and; Capabilities in the services system are not all well documented. The documentation of these capabilities would take much longer than the planned duration of the research. It is essential to provide a method to define variety

before embarking on an exercise of business process modelling and documentation so that variety is detected early and drives business process engineering and documentation rather than being subject to it.

To overcome the challenges noted above, the following research tools and instruments for capturing capabilities and perturbations are used in this research: Rather than use isolated individual interviews to define capabilities and perturbations, a workshop-style approach involving multidisciplinary key roles is adopted to obtain multiple valuable perspectives. To effectively capture varied perspectives and establish consensus, mind mapping tools and soft system methodology tools are used during these sessions; Perturbations and capabilities are justified by a measurable Key Performance Indicator and supporting data as far as reasonably possible. To ensure that this was fulfilled rather than capturing opinions, data are used to validate the ability to detect the perturbation or measure the capability performance; To cater for perturbations that are not easily quantifiable (i.e. the probability of a competitor), states are used in defining the perturbation indicator in two variables, namely current state and trajectory both presented as either desirable or undesirable. Defining system states this way allows for accounting for the variety even when the historical data does not exist for quantification and; rather than using detailed process documentation to define capabilities, a higher-level abstraction of capability is proposed. A capability is defined with a monitored performance indicator and corroborated by an expressed statement of the ability to have transitioned through an undesirable state to a desired one. This method of defining capability allows for the synoptic view of services systems as prescribed by the fourth principle of the VSM subsystems.

4.4.4 Validity and Reliability of Residual Variety Measurement

Variety Engineering (VE) is a mathematically calculative method used to identify residual variety (Ashby, 1958; Ríos, 2012). This is done by representing the service system as an abstract state machine (ASM). System capabilities or responses are defined as abstract-state-machine transition functions of the service system. The ASM representation of the service system is visually demonstrated as a 'black box' with inputs and outputs as discussed in Section 8.1. Variety is the combination of all possible ASM states in the service system, which is calculable. Defining all the possible inputs and outputs from a real industry service system presents an infinite amount of system states. A practical ASM definition simplifies systems to abstract calculable states at a useful granularity while maintaining the completeness of system representation (Boeger and Stark, 2003,

p. 12). A state variable is one of a set of variables that are used to describe the mathematical state of a dynamic system. In defining a system state, a state of a system needs to describe enough about the system to determine its current state and its future behaviour concerning other system states.

System states in ASMs are defined such that a system can only resemble one state at a time and the system is defined as a cohesive set of system states adhering to cybernetic systemic closure (Ashby, 1956, p. 11). System states are defined as mutually exclusive such that they are uniquely identifiable and to also ensure that specific action is taken to return the system to the desired system state (Beer, 1966). In conducting the workshops, it was useful to begin understanding the system by defining system states for analysing expected service system capabilities and areas of concern. As a result, service system inputs and outputs are defined, and an ASM is defined.

Boolean vectors that can take two variables, namely, current state (S) and trajectory (T) are used. These variables were agreed upon by the service teams. The diagrammatic representations are available later in the report in the results section. Nonetheless, the management teams decided on both the current state indicator and a trajectory state indicator. The defined system states make it more natural to quantify system variety to a level of granularity usable to a broad multidisciplinary audience. This also allows a calculation of a state variable to be defined as 'desired' instead of providing a target value because the value can change. Desirable accommodated for a multi-variable regulation of homeostasis.

The abstraction of states when defining desired and undesired states provide a tool to effectively integrate the analysis and the design of complex systems (Boeger and Stark, 2003). This method of describing a machine is known as Abstract State Machines (ASM). There are proven cases of its application in Software Engineering in translating sophisticated business requirements to intricately integrated system states (Boeger and Stark, 2003). The method provides a precise framework to communicate and document design ideas while using cybernetics for an accurate translation to a quantitative representation of complex systems (Boeger and Stark, 2003).

Using ASM, the variety of the system is calculable for VE. The matrix in Figure 17 is mapping disturbance (D) against response (R) and a set of possible outcomes (Z). Conceptually perturbation or disturbance changes a system state to an undesired state. A capability or response is then required to return a system to the desired state or a more desired state. The details in the mechanisms and processes used in doing the transition are not of concern in this type of cybernetic analysis. These

mechanisms are abstractly defined as transforms or 'machine with input', allowing for a systemic understanding of a system's behaviours (Ashby, 1956).

		R			
		r_1	r_2	r_3	...
	d_1	z_{11}	z_{12}	z_{13}	...
	d_2	z_{21}	z_{22}	z_{23}	...
D	d_3	z_{31}	z_{32}	z_{33}	...
	d_4	z_{41}	z_{42}	z_{43}	...
	...	...	...	...	...

Figure 17: Disturbances and responses matrix (Ashby, 1958)

"…cybernetics typically treats any given, particular, machine by asking not 'what individual act will it produce here and now?' but 'what are all the possible behaviours that it can produce? Once all the possible behaviours are identified, decision policies and measure can then be put in place that considers all possibilities concerning the risks they pose." (Ashby, 1956)

A modification, in Figure 18, of a disturbance and responses matrices, is used for checking whether adequate responses are put in place to cover all possible disturbances or perturbation (Ashby, 1956; Ashby, 1958) thus establishing viability.

Disturbances and Perturbations

		System States		
Original System State →		S1	S2 ...	S8
Disturbances Perturbations	D1	S7	S2	S8
	D2	S8	S2	S8
	D3	S1	S2	S10
	D4	S1	S9	S9
	...	...	...	...

Responses and Competencies

		System States		
Original System State →		S7	S8	S9
Responses Competencies	R1	S2	S8	S8
	R2	S7	S2	S8
	R3	S7	S8	S9
	R4	S7	S8	S9
	...	...	...	...

Figure 18: Linking disturbances and responses to system states

"Cybernetics envisages a set of possibilities much broader than the actual and then asks why the particular case should conform to its usual particular restriction. In this discussion, questions of energy play almost no part — the energy is simply taken for granted. Even whether the system is closed to energy or open is often irrelevant; what is essential is the extent to which the system is subject to determining and controlling factors. (Ashby, 1956)

Capabilities are transformation vectors that can transition a system from an undesired state to the

more desired one; perturbations do the opposite. In Figure 18, some hypothetic system states are defined (S1…Sn). Some of these system states are desired, and some are not. The undesirable system states are underlined. A disturbance or perturbation transitions a system from the desired state to an undesired one, whether it permanently or temporarily depends on the systems' ability to recover and maintain homeostasis. A list of disturbances (D1…Dn) is listed on the left matrix along with the resultant system states that are resulted from the disturbance. On the matrix on the right, a list of responses or capabilities is listed along with their transitions of system states.

A transition function is a mathematical representation of an abstract state machines' transition. In the case of capabilities, they are functions that can maintain the desired state over time or moving a system from one state to a more desirable state. On the other hand, perturbations (disturbances) are functions that transition a current state system to a less desirable one or maintain an undesired state over time. In analysis both the disturbances matrix and the responses matrix system recovery state transition paths are produced as in Figure 19 (Beer, 1985).

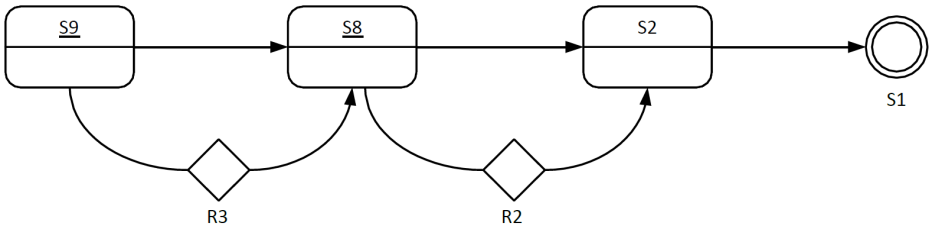


Figure 19: Recovery path from system state S9 to S2

4.5 A reliable method for identifying Residual Variety

The definition of the service system 'black box' allowed defining current service capabilities in line with what was expected from services. System states can now be defined, and capabilities can be mapped against the system states. Capabilities are transition states that either maintain a system in the desired state or moving it from an undesired one to a more desired one. Disturbances and perturbation, on the other hand, move transition the service system from a current state to a less desired one (Ashby, 1958; Stafford, 1966).

Classification of service system capabilities is now classifiable into cybernetic terms and allocable to the VSM model in terms of accountability. Mindjet MindManager 2019 and Excel 2016 are used to allocate capabilities into classifications. Cybernetics states were converted to statements using MS Excel, which service management could understand then in standard English language terms.

This made it simpler for the management to recognise areas of residual variety at a later stage when conducting Variety Engineering by juxtaposing capabilities and perturbations against the system possible system states. MindManager was used to allocate visually, through dragging and dropping, capabilities to the VSM systems and listing accommodated system states.

Using this method was very useful in identifying service system residual variety by involving multidisciplinary teams in workshops. The result is a mind map containing all the capabilities linked to system states, with their detailed descriptions in MS Excel, as demonstrated in Figure 20. Now Variety Engineering can be conducted. One, full workday, variety engineering workshops were held.

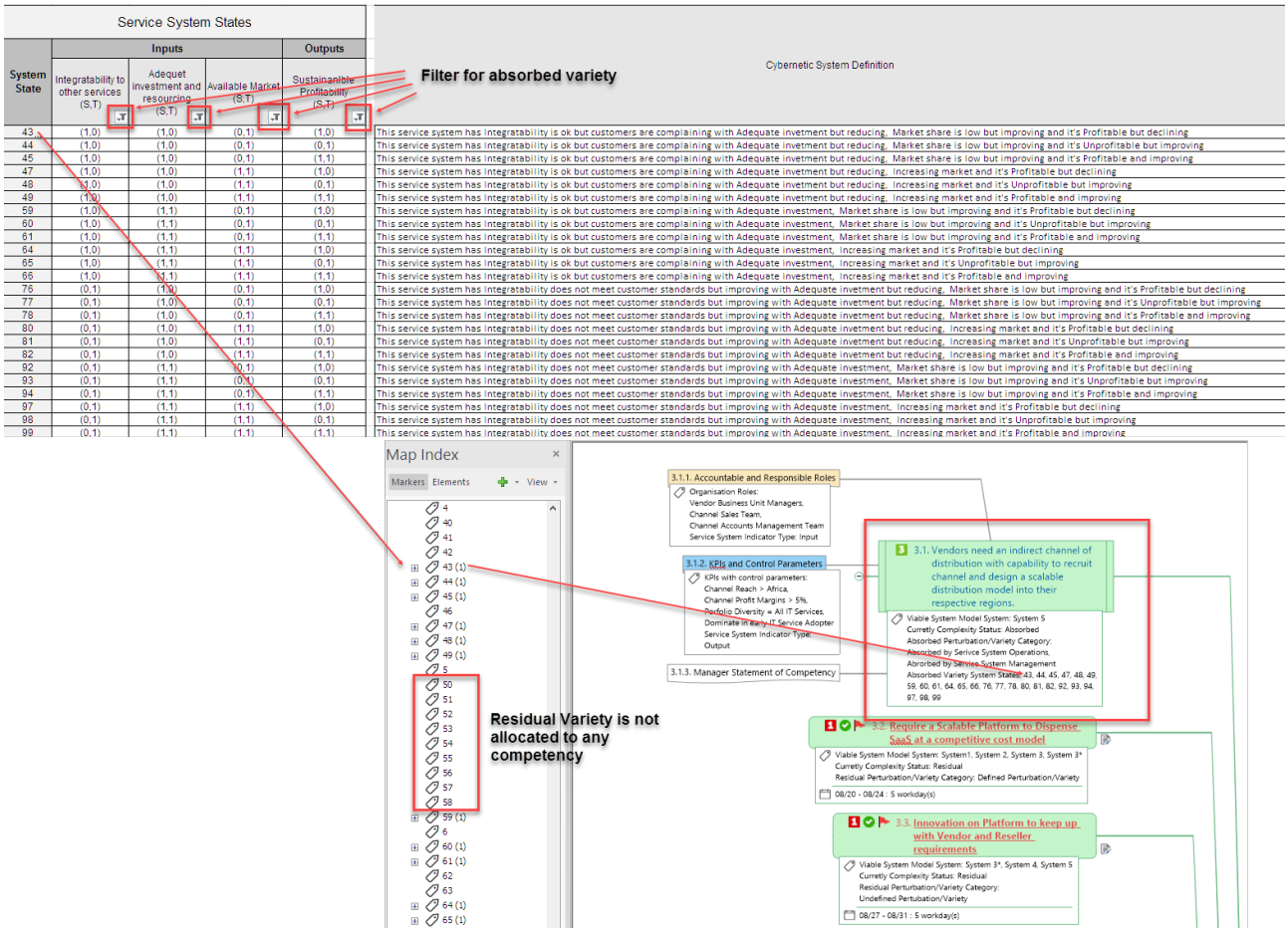


Figure 20: Using MS Excel and MindManager to Capture Capabilities and linking them to the Service System States

4.6 Principles applied in providing a conceptual design for viable IT service systems in South Africa

Having identified the IT service system configurations with residual variety, service system

redesigning is conducted using the VSM. The VSM approach makes use of charts such as the VSM charts and the Homeostatic Loops Analysis chart to produce viable systems conceptual designs. The process is systematic with iteratively applied principles throughout (Beer, 1985). The VSM is used to analyse and design a viable model with a design recommendation of each service configuration case. Exclusive interviews are conducted in cases where information is not available in documented best practices or research literature. One example is ascertaining the transducers that are currently used in the business. Interviews can ascertain useful information if no data, literature or documented solutions are unavailable. Three, full-day, service redesign workshops were conducted applying the following VSM organisation principles (Beer, 1985):

4.6.1 The First Principle of Organisation

"Managerial, operational and environmental varieties diffusing through an institutional system tend to equate. They should be designed to do so with minimal damage to people and cost." (Beer, 1985, p. 30)

Quantification of variety is required to uphold this principle. The Variety equations is used to determine varieties presented in the service system analysed. The approach is to view the service system as a 'black box', or ASM, with inputs and outputs. In Figure 21 there are two inputs and each can take on two variables (0, 1). Using Equation 1 the variety of the system is 16. This means that there are 16 different possible states the system can take on. The 16 different states are presented as rows in Table 4.



Figure 21: Variety Calculation Example

Using this example, systems can be abstracted as ASM with discrete inputs and outputs with the intent of quantifying the variety of the system. Variety can be calculated using Equation 1 or

Equation 2, below.

Table 4: Table of possible system states

Inputs:	00	01	10	11
	0	0	0	0
	0	0	0	1
	0	0	1	0
	0	0	1	1
	0	1	0	0
	0	1	0	1
	0	1	1	0
	0	1	1	1
	1	0	0	0
	1	0	0	1
	1	0	1	0
	1	0	1	1
	1	1	0	0
	1	1	0	1
	1	1	1	0
	1	1	1	1

Equation 1: Variety Equation 1 (Espejo and Reyes, 2011, p. 39)

$$V = (p^m)^{q^n}$$

Where:

V = variety of system

n = number of inputs in system m = number of outputs in the system

p = number of different values an output can take q = number of different values an input can take

Equation 2: Variety Equation 2 (Schwaninger, 2009, p. 12)

$$V = m \times \frac{n \times (n-1)}{2}$$

Where:

V = variety of system

n = number of elements

m = number of relationships between each pair of elements

To ensure the reliability of findings, all calculations are provided along with mathematical system state models and diagrams. Experienced IT service engineers are presented with simulation 'cockpit' type environment using a system dynamics model for validating service system design challenges. The Goldsim software is used for dynamically modelling service system behaviour and

complexity.

4.6.2 The Second Principle of Organisation

"The four directional channels carrying information between the management unit, the operation, and the environment must each have a higher capacity to transmit a given amount of information relevant to variety selection in a given time than the originating subsystem has to generate in that time." (Beer, 1985, p. 45)

This principle ensures that variety is not lost, or does not go undetected, in transmission or through transducers. All communication, calculation and conversion mechanisms in the organisation are required to carry all variety presented by the systems under management.

4.6.3 The Third Principle of Organisation

"Whenever information is carried on a channel capable of distinguishing a given variety across a boundary, it undergoes transducing; the variety of the transducer must be at least equivalents to the variety of the channel." (Beer, 1985, p. 47)

This principle ensures that all reporting mediums do not introduce 'noise', information delays or reduce the information being communicated. Reports are to present all the variety of the information being reported in near real-time as practically possible. Practically this implies the implementation of business intelligence tools, real-time analytics and automated messaging. Reports must allow the user to design the report to present the information as best suited for the analysis being conducted and provide the ability to apply parameters variables in the report to conduct useful analysis. The transducer, reporting tools, must at the least be able to cope with all the volume and variety of the information being transported and processed. This principle is applied in designing effective reporting and information processing system in the IT service system.

4.6.4 The Fourth Principle of Organisation

"The operation of the first three principles must be cyclically maintained in preventing oscillation through time without hiatus or lags. In homeostatic loop analysis, quantitatively enunciated homeostatic loops help deal with this variety: between blocks; along channels; across transducers

and with the whole process exhibiting appropriate cyclical dynamics." (Beer, 1985, p. 71)

"Homeostasis is that feature of an organism which holds some critical variable steady within physiological limits. The most usually quoted example is blood temperature. Whether we work in the refrigerators of a meatpacking station, or on the melting-shop stage in a steelworks, our body temperature remains 98.4° Fahrenheit." (Beer, 1966)

This principle prevents cyclical deviations from targets created by reactive or uncoordinated responses. Second-order learning and feedback mechanisms that consider internal service system dynamics need to be put in place to coordinate activities to maintain internal systemic homeostasis. This principle is applied through ensuring the service system decision policies are tested in SD models and implemented through the correct structures to achieve service system homeostasis.

In The Brain of the Firm, Beer (1972) applies the viable system model in a government context to install a preliminary system of information and regulation for the Chilean industrial economy. Beer intended to demonstrate the main features of cybernetics management to assist in the task of government decision making in 1972. In this process, Beer established five VSM subsystem principles, modified here to the application on service systems, in designing each subsystem, which is also applied in this research for re-designing service systems containing residual variety (Beer, 1972).

The subsystems are presented in the same sequence presented in The Brain of the Firm (Beer, 1972).

4.6.5 The First Subsystem Principle – Subsystem 5

"Subsystem 5 within a service system governance cannot be elite, and it is to be the embodiment of the values of the other services and services systems themselves." (Beer, 1972, p. 288)
This principle prevents governance systems subjecting the system to compliance contradictory to its identity or viability. There must be self-reference of viability at the governance level. This design principle implies that System 5 be aware and representative to lower embedments and lower subsystems. In practical terms, the principle is applied by ensuring that service system management and leadership be representative to service system values, identity and ethos. Service system leadership must 'walk the talk' and have empathy. The decision policies that System 5 applies must

contain accurate reference models closely resembling the internal mechanisms and complexities existing inside the service system.

4.6.6 The Second Subsystem Principle – Subsystem 2

"The speed of the response in an essentially lagged servomechanism is critical. Subsystem 2 is to ensure anti-oscillatory feedback control." (Beer, 1972, p. 288)

This principle is applied in designing effective, 'as real-time as possible' reporting and information processing systems in the IT service system.

4.6.7 The Third Subsystem Principle – Subsystem 1

"Variety engineering enables us to design homeostatic subsystems that obey the Law of Requisite Variety and determine a recursion of metasystems. These homeostatic sus-system preserves the autonomy of Subsystem 1 subsystems and while maintaining a structural fractal recursion." (Beer, 1972, p. 288)

This principle is applied through creating competencies and capabilities that absorb specific complexity. Autonomy must not be seen as hierarchically static, but through complexity management, organisational structures must permit be self-organising to tackle residual complexity as and when it arises. Structural adaption is a vital mechanism to absorb complexity. This principle is applied in establishing an organisation structure while allowing self-organisation and adequate autonomy.

4.6.8 The Fourth Subsystem Principle – Subsystem 3

"Command is matter neither of wielding authority nor of overloading the central axis with variety-attenuation regulations. System 3 delegates authority and accountability to the elemental level and looks for synergistic advantage by taking a synoptic view of System 1." (Beer, 1972, p. 289)

This principle ensures that there is a coordination function in the service system that promotes synergy between service subsystems. This principle was applied in recommending scheduling and business process management tools to coordinated activities that require involvement or

participation of multiple service subsystems and recommending regular meetings that cross-pollinate knowledge and information across service metasystems to service subsystems, and between service subsystems.

4.6.9 The Fifth Subsystem Principle – Subsystem 4

"Special attention is necessary to Subsystem 4 otherwise, Subsystem 5 identifies with Subsystem 3. A transgression on this principle will result in the whole cerebral meta-structure collapse instead of adapting and self- determination, and if that happens we are left with crisis management, the lack of proactive adaptive management." (Beer, 1972, p. 289)

Second-order learning and feedback mechanisms that consider internal and external service system dynamics need to be put in place to coordinate activities to maintain both internal systemic homeostasis and service system relevance. This principle is applied through ensuring the service system decision policies in Subsystem 4 are tested in SD models and implemented through the correct structures to achieve service system homeostasis through proactive adaptive management.

4.7 Ethics

Ethics clearance for this research was obtained, which included consent from participants of this research. Company permission was also obtained to use aggregated qualitative information for this research.

The University of the Witwatersrand ethics clearance number for this research is MIAEC 061/18

5. RESULTS

5.1 Responses from Capabilities and Perturbation Questionnaires

Firstly a Capabilities Questionnaire (available in Appendix G – Questionnaire used on focused interviews on assessing Capabilities and Competencies in IT Service Business Units and Departments) was used in focused interviews with business unit managers from each service system and other selected participants. Then a Perturbation Questionnaire (available in Appendix H – Focused Interview Questionnaire for Service System Perturbations) was used in focused interviews with business unit managers from each service system and other selected participants. Four executives and three senior managers, three business unit managers and two principal partners were interviewed in person (a sample of one of the interviews is available in Appendix J – Focused Interview Questionnaire for Service System Capability).

These individuals were selected based on their strategic and current responsibilities on growing the cloud business in the organisation. Pseudo names such as Executive 1 and Vendor 1, and so forth are used to protect the identities of individuals and intellectual property of the businesses. Having captured the interview data, when analysing the responses, common issues were evident across all service offerings, which were also validated in the workshops that followed. The recurring expressed challenges in delivering the IT services were the following:

- "Resellers are complaining about billing discrepancies on the platform resulting in refusal of payments. Non-payment impacts profitability." This point can also be seen in supporting summary statistics (in Appendix L – SaaS Service System Support Ticket Volume Contributions).
- "Certain functionality in the portal is cumbersome and results in Resellers calling in rather than using the platform. This inundates support and specific staff within the service business units." This was also supported by support ticket data.
- "Reseller and partners easily move their transactions to other VADs or go direct. Customer churn is concerning as it results in an abrupt loss in the cloud business. Once the customer leaves, it's hard to get them back" This can also be seen in reported revenue drops per customers.
- "Resellers do not understand their invoices and various charges in their billing, as a result,

they call in, and I direct them to support since I do not know how to help them." This is also seen in summary statistics in Appendix L.

- Internal staff supporting the backend platform manual processes were under much pressure and complained to their management. Some expressed their frustrations in the workshop sessions that followed.
- There was a common perception that more staff was required to either support the platform or develop better features.
- Sales teams did not know how to generate demand for cloud business through their calls and customer meetings. This was experienced even at partners.
- Most of the support queries took weeks to resolve going back and forth between departments. Ticket resolution times were long, and there were high repeat occurrences.
- Partners wanted specific vendors on the platform, and the Digital Team was taking too long to avail these vendors on the digital platform.
- One Business Unit Manager was complaining about why it was taking so long to build a platform for his vendor.
- Some service managers proposed that processes needed re-engineering and KPIs realigned to support and incentivise prioritising the cloud business as opposed to traditional licensing models. Currently, cloud business was not a priority because sales and operations were not incentivised on it.

5.2 Abstract State Machine (ASM) definition from service system workshops

The results from the workshops discussing the service system challenges produces the ASM definition of the system presented in Figure 22. Three inputs are defined, each taking on a set of two Boolean variables. The first variable (S) presented the current state of that input to be either undesirable '0' or desirable '1'. The second (T) presented whether the trajectory or current trend line of the input is '0' undesirable or '1' desirable.

On the output side, sustainable profitability was the single output defined by the workshop participants. Conversations also made mention of customer service, but the consensus was that this was inclusively measured in Integratability as the B2B model that meant the VADs customers were service-based. These state variables had very sophisticated calculations behind them, but they reflect the granularity and comprehensiveness of performance indicators that executive management use to allocate funds into the service system.

Even with the few variables, the resultant variety was 256 system states, also called variety (Ashby, 1958), of which 132 were undesirable, and 118 were residual, (details in Appendix Q – Service System States). Using Microsoft Excel to list all the combinations of inputs and outputs that were obtained from the results of the workshop. The ASM inputs the workshops came up with are Available Market, Adequate Investment and Resourcing, and Integrability to Other Service Systems while the output was Sustainable Profitability. The inputs and outputs are discussed in more detail in the discussions section.

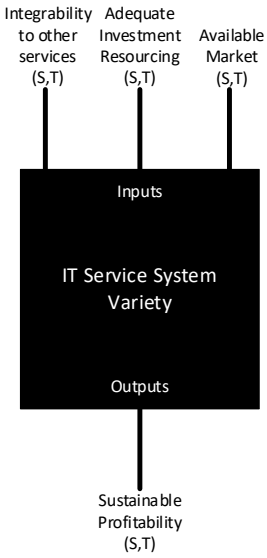


Figure 22: 'Black box' presentation of the Viable IT Service System from Executive Management workshops

It is worth noting that using the variety calculation from Espejo (2011), Equation 1, a variety of 256 is obtained, same as the excel analysis which also produces 256 states as presented in Table 5, which validated the equation. As a result, the equation demonstrates the exponential nature of variety in relation to the number of inputs and outputs in a system.

Table 5: Service System Variety in MS Excel with Duplications Removed

Service System States					Cybernetic System Definition
	Inputs			Outputs	
System State	Integratability to other services (S,T)	Adequate investment and resourcing (S,T)	Available Market (S,T)	Profitability (S,T)	Complete Service System State Definition
1	(1,1)	(1,1)	(1,1)	(1,1)	This service system has Integratability that can scale with Adequate investment, Increasing market and it's Profitable and improving
2	(1,1)	(1,1)	(1,1)	(0,1)	This service system has Integratability that can scale with Adequate investment, Increasing market and it's Unprofitable but improving
3	(1,1)	(1,1)	(1,1)	(1,0)	This service system has Integratability that can scale with Adequate investment, Increasing market and it's Profitable but declining
4	(1,1)	(1,1)	(1,1)	(0,0)	This service system has Integratability that can scale with Adequate investment, Increasing market and it's Un-Profitable and getting worse
5	(1,1)	(1,1)	(0,1)	(1,1)	This service system has Integratability that can scale with Adequate investment, Market share is low but improving and it's Profitable and improving
6	(1,1)	(1,1)	(0,1)	(0,1)	This service system has Integratability that can scale with Adequate investment, Market share is low but improving and it's Unprofitable but improving
7	(1,1)	(1,1)	(0,1)	(1,0)	This service system has Integratability that can scale with Adequate investment, Market share is low but improving and it's Profitable but declining
8	(1,1)	(1,1)	(0,1)	(0,0)	This service system has Integratability that can scale with Adequate investment, Market share is low but improving and it's Un-Profitable and getting worse
9	(1,1)	(1,1)	(1,0)	(1,1)	This service system has Integratability that can scale with Adequate investment, Market that's ok but declining and it's Profitable and improving
10	(1,1)	(1,1)	(1,0)	(0,1)	This service system has Integratability that can scale with Adequate investment, Market that's ok but declining and it's Unprofitable but improving
11	(1,1)	(1,1)	(1,0)	(1,0)	This service system has Integratability that can scale with Adequate investment, Market that's ok but declining and it's Profitable but declining
12	(1,1)	(1,1)	(1,0)	(0,0)	This service system has Integratability that can scale with Adequate investment, Market that's ok but declining and it's Un-Profitable and getting worse
13	(1,1)	(1,1)	(0,0)	(1,1)	This service system has Integratability that can scale with Adequate investment, Low market availability and declining and it's Profitable and improving
14	(1,1)	(1,1)	(0,0)	(0,1)	This service system has Integratability that can scale with Adequate investment, Low market availability and declining and it's Unprofitable but improving
15	(1,1)	(1,1)	(0,0)	(1,0)	This service system has Integratability that can scale with Adequate investment, Low market availability and declining and it's Profitable but declining
16	(1,1)	(1,1)	(0,0)	(0,0)	This service system has Integratability that can scale with Adequate investment, Low market availability and declining and it's Un-Profitable and getting worse
256	(0,0)	(0,0)	(0,0)	(0,0)	This service system has Bad integratability and frustrating customers more with Inadequate investment and getting worse, Low market availability and declining

Using the equation

$$V = (p^m)^{q^n}$$

Where:

V = variety of system

n = number of inputs in the system

m = number of outputs in the system

p = number of different values an output can take q = number of different values an input can take and substitute in the values

$$V = (2^1)^{2^3}$$

One obtains the same number is system states as

V = 256

which is the same as obtained in the Excel spreadsheet for analysis. In summary, results from discussion and workshops were captured as inputs and outputs and using an Excel spreadsheet analysis, the results in (Appendix Q – Service System States) were obtained.

5.3 Perturbations and Responses from Workshop presented as State Transition Vectors

Table 6 is the list of perturbations provided from the Variety Engineering workshops in no specific order. Some of the information has been replaced with pseudo terms such as 'Response 1' because this is currently considered company intellectual property.

Table 6: List of Perturbations provided in Workshop Sessions

	Perturbations	Detection Method Available	KPI used to detect this	Impact		Response	Resultant System State after response
				Current System State	Resultant System State		
1	Vendors release products with new billing models that aren't accommodated for in the ERP	Yes - Before the fact	KPI 1	S23, S12	S118	Response 1	S_{ZZ1}
2	Unstable economy, internet become un-affordable	Yes - After the fact	KPI 2	S_{XX1}	S_{YY1}	Response 2	S_{ZZ2}
3	A reseller or a partner consumes more services than they can afford and it is not possible to pick this up early	Limited - After the fact	KPI 3	S_{XX2}	S_{YY2}	Response 3	S_{ZZ3}
4	Loosing resellers because we don't have a feature that is available in the platform of a competitor	Yes - After the fact	Report	S_{XX3}	S_{YY3}	Response 4	S_{ZZ4}
5	New competitor in the market outside the current competitor profiles that we normally focus on	Yes - After the fact	None	S_{XX4}	S_{YY4}	Response 5	S_{ZZ5}
6	A key business manager resigns and business loosed the intellectual property along with the employee	Yes - After the fact	KPI 4	S_{XX5}	S_{YY5}	Response 6	S_{ZZ6}
7	Skills are rear in the market of people that can develop services and manage them	Limited - After the fact, when roles is required	None	S_{XX6}	S_{YY6}	Response 7	S_{ZZ7}
8	Providing a services becomes uncompetitive because someone else provides the same service for cheaper	Limited - After the fact	None	S_{XX7}	S_{YY7}	Response 8	S_{ZZ8}

5.4 Service System Redesign using the proposed Viable System Model

The service system redesign workshops and focused interview produced several models and charts which are cited below with details provided in the respective appendices.

It should be noted that these are not in any specific sequence since the iterative process of design, redefinition and redesign may produce these charts in any sequence.

5.4.1 The Model of Systemic Control (MSC)

(Appendix K – IT Service System Model of Systemic Control)
The result indicated the incorporation if the ASM inputs and outputs into the MSC model. SD models are incorporated into the MSC model to incorporate the dynamics between the defined inputs and outputs in the performance management of the service system.

5.4.2 The Causal Loop Diagram (CLD)

(Appendix M – Service System Causal Loop Diagram (CLD))
The result is a causal loop diagram that considers all the elements, with the interactions between them that contribute to the performance of the IT Service System.

5.4.3 A representation of the SD model design

(Appendix N – Service System SD Model)
The result is an SD model, here only presenting a sub-model that simulates service system dynamics. In the sub-model presented, the impact of releasing new features on customer service level times is modelled.

5.4.4 The IT Service System Triple Embedment

(Appendix P – IT Service System Triple Embedment)
The results indicate that the B2B IT Service Systems has cloud service models as viable service subsystems. The cloud service offerings under the B2B IT Service Systems are the same service models that are found under the (Information and Technology Industry – Direct Distribution

Channel – Vendor) vendor service systems embedment. The B2B service system is part of a higher embedment service system, namely ICT Service Provider. The higher embedment subsequently embeds into the ICT Industry. The triple embedment reveals all the viable entities in the industry. The triple embedment was refined over several session such that a consistent definition of viability is upheld throughout all embedments layers.

5.4.5 The service system design session produced the service system VSM Model

(Appendix R – IT Service System VSM)
The result is a VSM model containing the detailed blueprint of the recursive structure, interactions, functions and service subsystems required for establishing a viable IT service system.

5.4.6 The Homeostatic Loops Analysis chart

(Appendix S – IT Service System Homeostatic Loop Analysis)
The result is a homeostatic loop analysis chart containing input and output transducers, attenuation and amplification mechanisms, required to maintain homeostasis in the viable service system.

The next chapter discusses the findings and results of the research.

6. DISCUSSION OF FINDINGS

In the research process, VSM concepts and mechanisms had to be applied not only to the redesign of the service system but also to refine the methods utilised in the collection of data and information. Initially, focused interview questionnaires were used to assess whether service system issues existed in the organisation. At a later stage of this study, mind-maps were used to document and analyse information from workshop sessions. The VSM approach in itself prescribes a research methodology that defines how information is collected, analysed and processed. The implications are that the tools and mechanism prescribed by the VSM are applicable in service system operational research.

Another key finding was that the VSM concepts proved rather challenging to grasp to most participants. Much of the effort invested in this study was in teaching the VSM along with other cybernetic concepts to participants. Repeated application and individual training feedback sessions contributed to how well the participants grasped the concepts. This has to be catered for in such an exercise. Much of the manual gathering of data must be automated as far as possible to provide a continuous and scalable diagnosis of viability within IT service systems. Decision Support Systems are to contain effective representative system models to implement automated adaptive service systems management.

It should be noted that such initiative is expected to be met with much resistance but using cybernetic models such as the Syntegrity model allows collaborative and multidisciplinary participation at all levels of business because cybernetic models provide a common platform for communicating complex systems, their behaviour, organisational structure and how they can be managed. A collaborative approach reduces blaming and focuses the participants on system analysis for understanding.

6.1 ASM Inputs and Outputs Discussion

This section discusses the inputs and outputs collected from the workshop sessions in more detail. Figure 22 is the produced ASM presentation of an IT service system. Three inputs are provided, namely Available Market, Adequate Investments and Resourcing, and Integrability to other services, with a single output, namely Sustainable Profitability. Each input and outputs variable contains two-state variable namely current state ‘S’ and trajectory ‘T’.

The inputs and outputs are discussed in more detail in the following sections.

6.1.1 Available market

Available market is the amount of market opportunity that is translatable to sales. This can be increased by careful investment in the service system capabilities that promise higher market opportunity and are appropriable (Christensen, 1997; Christensen and Raynor, 2003; Furr and Dyer, 2014; Christensen *et al.*, 2015). The reason the available market is defined this way is that it was clear that investments were being made in service systems without adequately understanding how much return on investment would be yielded and how soon. According to Furr and Dyer (2014), innovative methods are required to assess the market with limited risk to the business.
Participants considered the available market to be crucial with the majority saying that more resources were required in analysing the available market. A question was raised in the workshop "…how do we analyse market availability currently?" One participant noted the report challenges "…I really do not know what I am supposed to do with that customer report because it does not tell me why the customer chose to buy the product. It just tells me they bought. " It was found that conventional market analysis tools were being used which some of the participants questioned regardless of resourcing. The issue was not resourcing but rather the assumptions and techniques applied in understanding markets. New methods were proposed to understand market dynamics and how this contributed to consumer behaviour.

6.1.2 Adequate investment and resourcing into the service system

"I will not give you a resource unless you show me how this person is going to either monetise your business or scale your business." One executive made this statement in the workshop sessions in response to a service system manager complaining about not having enough resources. Despite the comment, even the executive, along with all the other participants agreed that adequate investment and resourcing is another critical input. The executive stressed the term 'adequate'.
Without adequate investment in the service system, this results in increased time to market and reduces customer service levels but on the other hand, careless resourcing results in more further challenges. Investment and resourcing capture all investment into the service system that enables it to generate sustainable profits. A wrong decision made here can result in starving the service system of capability while overspending on a capability that is not justified. According to Furr and Dyer

(2014), a balance is important and the service system should ensure monetisation of services within committed time frames.

6.1.3 Integrability into other service systems

Integrability is an indicator of how easily other service systems and customers can consume the services on the service system. Ease of transacting is key, and scalability of business processes is fundamental to achieving this. Integrability, according to the participants, also encapsulated a component of customer service. Improving the integrability of the service system involves business process engineering in the back-end and having the flexibility to integrate automated and semi-automated business processes supporting the platform.

In another sense, Integrability also talks to the complex consumption models, supporting multi-tier, sophisticated pricing rules that allow the billing of services across the available multitude of consumption models. Partners require live information feeds to be able to offer adaptive and responsive 'pay as you use' service offerings while accurately billing their customers. On the other hand, service managers want to reduce complexity in their systems because providing all these features introduced more complexity when done in-house. All this is incorporated under the integrability input, and a service system should be able to ensure adequate integrability to other services systems. This would also allow service systems to leverage other services systems external to the organisation. All participants in the workshop agreed that this was necessary.

6.1.4 Sustainable Profitability

Profitability is the monetary gains from providing a service, considering the total cost of delivering the service. The sustainability in the term ensures that short term gains do not trump long term gains. Participants agreed that a long term view is required for profitability. Current profitability can be positive and grow month on month, but it does not mean that the profitability is sustainable. A component of profits at risk is required to measure sustainable profits. Profits at risk consider competition, profits that can be lost from losing an employee because business processes are not captured in business systems. The indicator also allows for taking profit losses now on specific deals to lock future business but not at the detriment of current business.

Given that IT service system operates in dynamic markets, it is reasonable to expect that investment is made regularly to maintain relevance for future business.

6.2 Variety Engineering Discussion

The objective of the perturbation list that was produced out of the workshop, Table 6, is to identify resultant system states that introduce residual variety. A comment was made in a focused interview with an executive session. "… surely there are system states presented here that are not possible". "How can we have all input variables as undesirable and not improving and yet have sustainable profitability?" Such a statement may be initially interpreted as accurate unless perturbations are introduced as part of the analysis. An example that was provided in a workshop session was an introduction of a disruptive service system, a new innovative start-up in the market, which was later found to create precisely such a state. The ASM, along with the introduction of perturbation analysis is vital for highlighting such cases where residual variety is not apparent. It proved to be a reliable method for identifying residual variety that would otherwise remain hidden.

It is important to note that system states are also time-dependent. This was raised in the form of a question in the workshop sessions as follows, "What happens when… while recovering from a system state to a desired one, another disturbance hits the system". Another participant replied, "…this means that the system could end up in a different more dire state; hence catering for all system variety as far as possible ensured a robust system". The next follow up question was then, "What if the disturbance is sustained beyond the ability to recover sustainable profitability?" An example of this is a stretched elastic band pulled until it snaps. To which another attendee replied. "We need to define a system state of a 'snapped' or irreparable systems state and then decide whether in such a case we would want to reprioritise resources of that service system or abandon it entirely based on certain underlying conditions. We need to put measures in place to detect undesired states early such that we are proactive than reactive. This will allow us to design a viable system that cannot 'snap'. That is where this approach is so powerful because we can define decision policies upfront to cater to such a state if such a state is unavoidable…" From these conversations, it can be seen that the participants were not only grasping the cybernetic concepts but were learning to apply them as useful abstraction tools to better understand systemic behaviour. Which means the participants understood variety and its impact on the ability to understand manage complex systems.

Having completed the Variety Engineering Analysis, it was found that all other service systems contained the same residual variety. The effects from the residual variety were experienced but not clearly articulated or responded to because consideration was never made for the residual variety. The ASM methods helped clarify the residual variety that existed. Defining the service system as an ASM proved significant in identifying residual variety that would have otherwise gone undetected.

The next section discusses the IT service systems model (Appendix R – IT Service System VSM) designed by applying the viable system model to IT service system design.

6.3 Service System Design Recommendations

The results of applying the VSM model to designing a viable IT service system produces six design artefacts namely, an MSC diagram, a CLD schematic, an SD model, a system triple embedment schematic, a VSM diagram and a homeostatic loop analysis chart. These are created in any sequence depending on why and how the design process is imitated.

This section discussed the design recommendations made in more detail through a number snapshots from the resultant Viable System Model Chart. Under each subsection, a system recommended design is discussed, referring to viable system model principles of organisation and subsystem principles. All the relevant charts referenced in this section can we found in the Appendix as follows:

- Appendix K – IT Service System Model of Systemic Control
- Appendix M – Service System Causal Loop Diagram (CLD)
- Appendix N – Service System SD Model
- Appendix P – IT Service System Triple Embedment
- Appendix R – IT Service System VSM
- Appendix S – IT Service System Homeostatic Loop Analysis

The next subsections discuss the results of each System design within the VSM model.

6.3.1 System ONE Design

The IT Service Provided B2B System, System 1 design is represented in Figure 23. The result is that System ONE is made up of System ONE Operations and System ONE Managements linking into the IT Service Provider B2B Management System. The other result is that System ONE is made up of viable service subsystems, namely SaaS, PaaS, IaaS and ITaaS. Under each subsystem, there are subsystems, namely Cloud, On-Premise, Hybrid and a Solutions Development Unit. This continues into lower-level embedments, but all are maintaining the same service system unit of viability. This implies a joint base of service system referenced identity and performance as defined by the AMS produced in Figure 22. Each viable service system unit has the same inputs and must produce sustainable profits within its market as an output even at lower embedments and higher embedments.

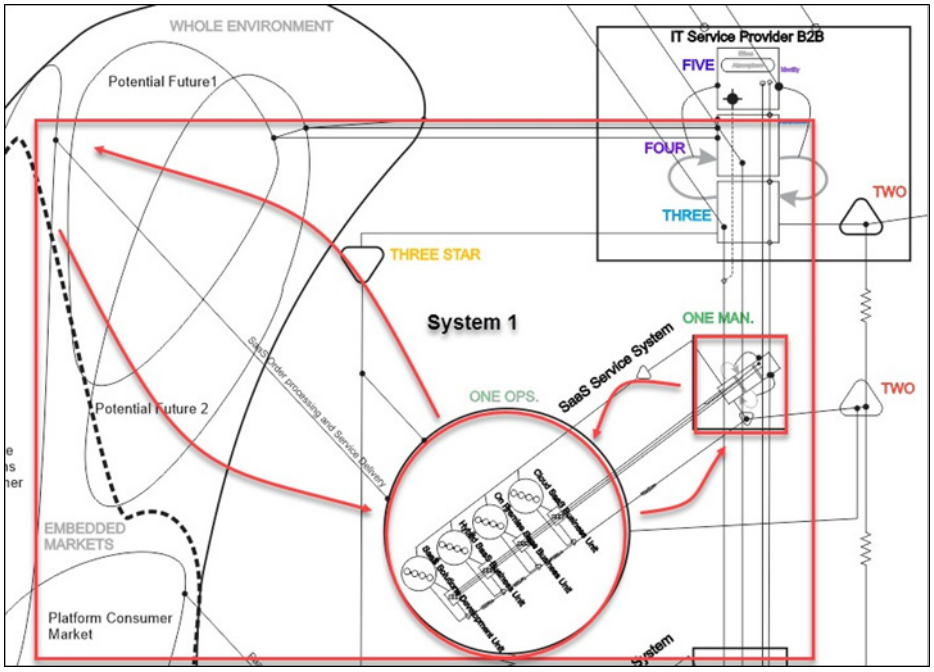


Figure 23: Viable System ONE Design of the IT Service Provider B2B

Design recommendations proposed regarding System ONE Design:

All service systems and subsystems are to adopt the same objectives and performance indices as presented in homeostasis analysis chart. Every service system unit is responsible for generating sustainable profits.

- Each Sub Service System is to have the same KPIs and homeostatic loop mechanisms as System ONE but for their particular service systems. The homeostatic loop analysis chart of the redesigned IT B2B service system can be

found in Appendix S.

- Each Sub Service System is to have its management with the same management KPAs as System ONE but at the sub-system level.

- While System ONE management performs normative and strategic management for System ONE, each sub-system is also to have its own normative and strategic management with a limited scope of services provided by the System ONE but with regular planning sessions with System ONE management.

6.3.2 System TWO Design

The IT Service Provided B2B System, System TWO, in Figure 24 contains all the coordination and harmonisation linkages into all the service subsystems. The result is every System TWO for each subsystem links into other service subsystem System TWOs and all link into the management system, System TWO. This structure implies that a co-ordination and collaboration platform must be established to harmonise activities across all service subsystems, the management system and the service metasystems. The sub-service system is also to be aware of each other service systems and establish synergist relationships with them while maintaining individual viability.

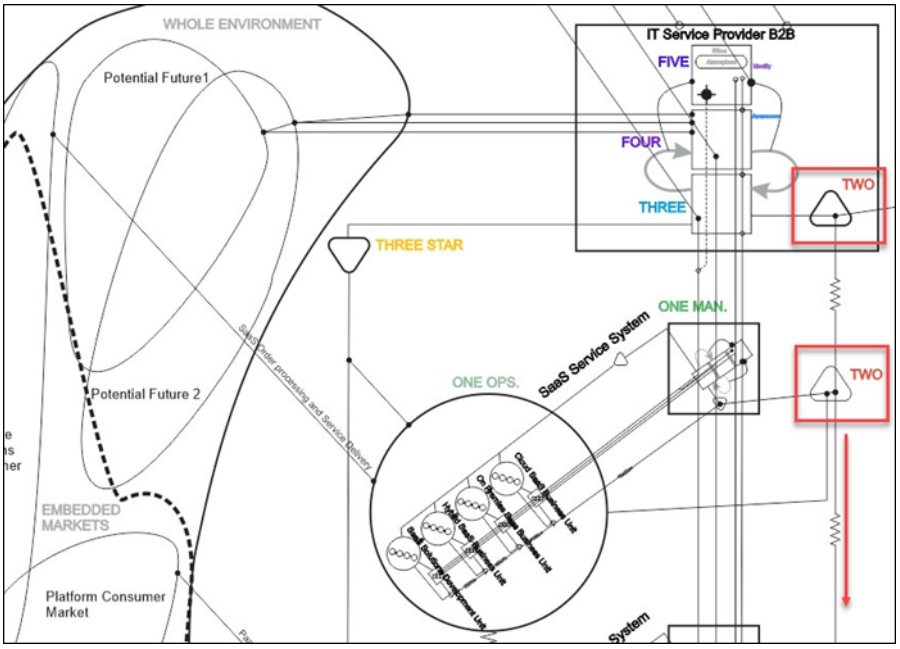


Figure 24: Viable System TWO Design of the IT Service Provider B2B

"The speed of the response in an essentially lagged servomechanism is critical. System 2 is to ensure anti-oscillatory feedback control." (Beer, 1972)

Design recommendations proposed regarding System TWO Design:

- All management it to be taken to systems thinking training to create awareness of counter-intuitive decision making, theoretical system pathologies and system thinking tools for improving decision making for achieving desired emergent systemic behaviour

- The business is to invest in SD modelling tools and expertise for training management on the impact of their current decision making such us to prevent counter-intuitive decision making.

- SD models are to be used to test decision making assumptions. The SD models are built to be a valid abstract representation providing the service system dynamics and the impact of reactive, delayed decision making.

- Regular collaborative meetings are to be established where cross sub-system projects and activities can be coordinated. A standard template is to be provided where high-level activities and projects can we consolidated at sub-system level reporting back to System ONE Management. The template must present all four parameters as defined in the ASM definition, namely: (1) Integrability; (2) Available Market; (3) Investment; and (4) Profitability.

6.3.3 System THREE Design

The IT Service Provided B2B System, System THREE in Figure 25 (Integration) performs a harmonisation role exploiting possible synergies form the interactions of System ONE subsystems. System TREE may be considered the "Operational Management" of the organisation. The result is that System THREE has audit checks through System THREE for each subsystem service. This system is concerned with the daily operations. It is concerned with the organisation "here" and "now" (Ríos, 2012, p. 32).

"Command is matter neither of wielding authority nor of overloading the central axis with variety-attenuation regulations. System THREE delegates authority and accountability to the elemental level and looks for synergistic advantage by taking a synoptic view of System ONE." (Beer, 1972)

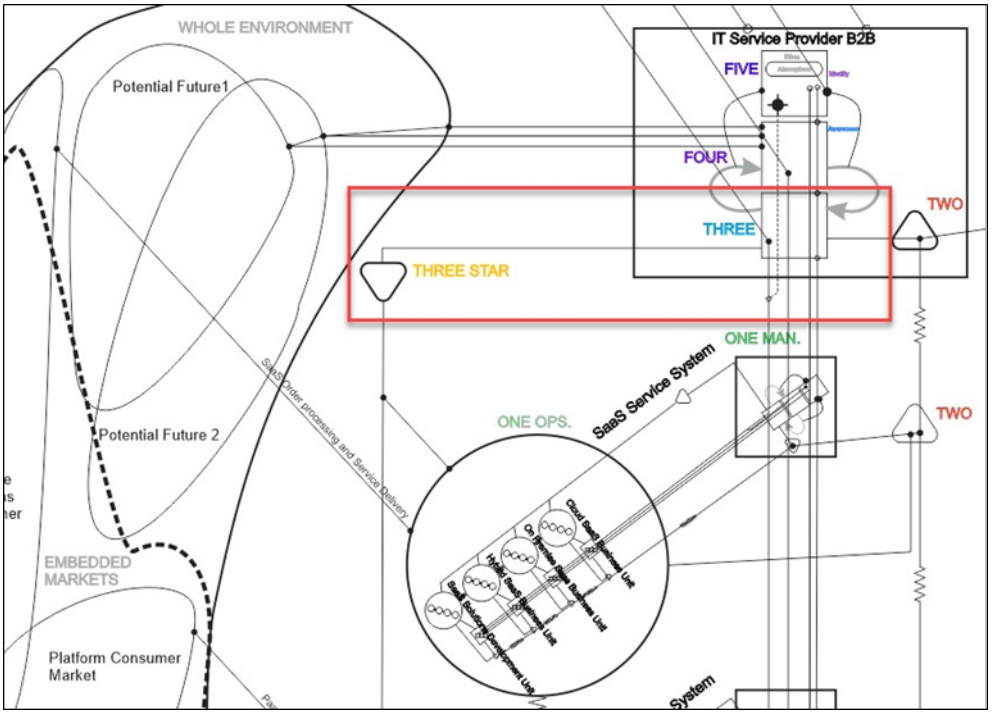


Figure 25: Viable System THREE Design of the IT Service Provider B2B

6.3.4 System THREE STAR Design

The IT Service Provided B2B System, System TREE STAR in Figure 26 is a support system for System THREE, and its primary mission is to obtain information from System ONE and its service subsystems. This accommodates for information which cannot be accessed via communication channel linking System TWO and System THREE. Although the information on how System ONE is working should reach System THREE via normal information channels, System TWO and accountability, there is a chance that part of this is filtered and does not get to System THREE. System THREE STAR must be designed to solve this problem (Ríos, 2012, pp. 35–36).

"The qualitative difference regarding the information provided by System THREE STAR is that it is not of a "routine" nature and affects the whole of System ONE, even if it is picked up in each of the elementary operational units. It supplies information that cannot be supplied either by System ONE or System TWO." (Beer, 1972)

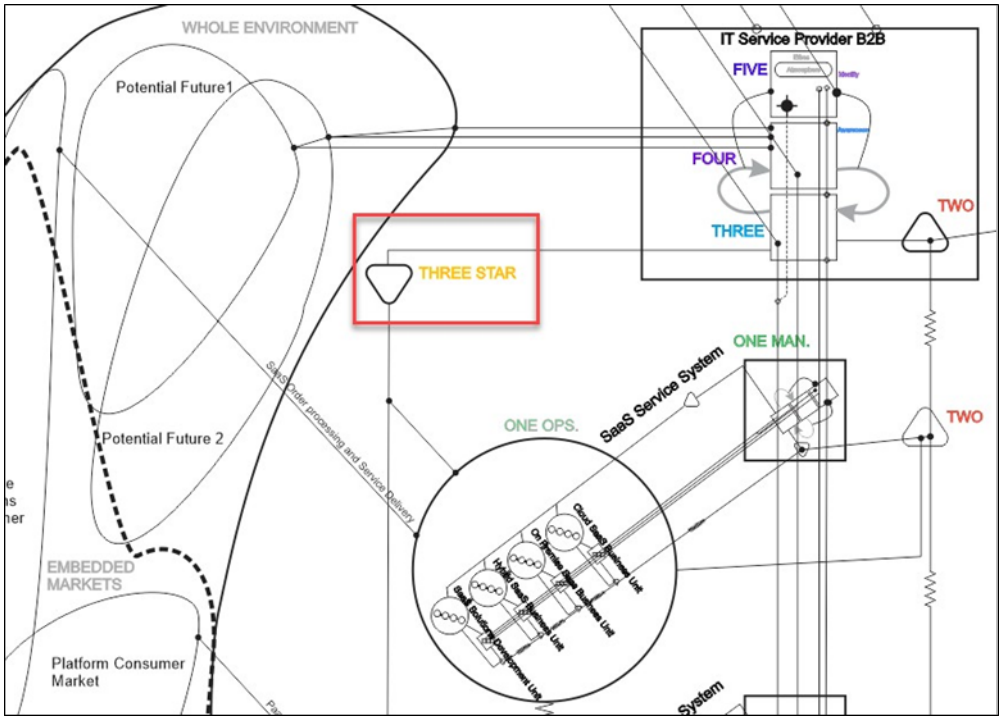


Figure 26: Viable System THREE STAR Design of the IT Service Provider B2B

Design recommendations proposed regarding System THREE and THREE STAR Design:

- Audit mechanisms must put in place to perform sporadic auditing for every service subsystem that would other no be picked up through System TWO reporting.

- The audit function THREE STAR also verifies information from operational environments for System THREE learning and foster synergistic behaviour between service systems

6.3.5 System FOUR Design

The IT Service Provided B2B System, System FOUR. System FOUR (Intelligence), in Figure 27, represents the organisation's adaption structure. To do this, the organisation must monitor both what is currently occurring and possible future changes subject to the appropriate environment. The result is System THREE 'detection' points into the current and potential future markets. Another result is a homeostatic loop analysis between System FOUR and System THREE to coordinate service system activities to adapt to the market environment. This system contains the right tools and methods to process and analyse information, variety and complexity presented by the

organisation and its environment. The translation from data to information, to modelling and intelligence, is performed here (Ríos, 2012, p. 40).

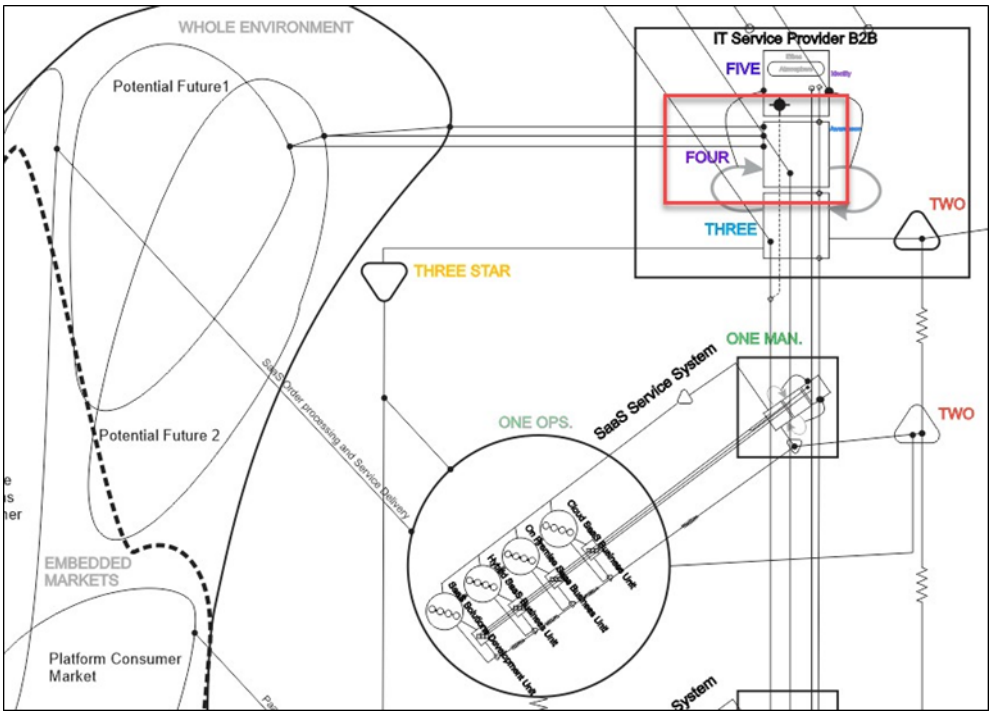


Figure 27: Viable System FOUR Design of the IT Service Provider B2B

"Special attention is necessary to System FOUR otherwise, System FIVE identifies with System THREE. This will result in the whole cerebral meta-structure collapse instead of adapting and self-determination, and if that happens we are left with crisis management, the lack of proactive adaptive management." (Beer, 1972)

Design recommendations proposed regarding System FOUR Design:

- The maintenance of Causal Loop Diagrams and SD models is to be done by a multidisciplinary team of elected representatives from each department. The SD model is to be updated as soon as residual complexity is detected either by the SD model or through other avenues such as marketing and support departments.

- The SD model is to be linked to the internal business system so that deviations between the models and real data can be detected. Revealed residual variety may require model refining or Service System redesign.

- A multidisciplinary team must also be used to ensure investment in transducer mechanisms that detect residual complexity and contextualise it accurately. The selected multidisciplinary team is to be trained in SD modelling and provided access to integration technologies that can assist in getting data from business systems as when needed.

- Deviations detected from the SD model are to output precise actionable diagnosis of residual variety to either System THREE or System FIVE.

6.3.6 System FIVE Design

The IT Service Provided B2B System, System FIVE (Policy) in Figure 28 has supreme authority in the organisation. All variety that all the other subordinate functions cannot absorb is resolved by System FIVE. System FIVE's function is to balance the present and the future of the organisation, or 'the bigger system in focus. As a result, System FIVE produces the service system's awareness through interacting with System FOUR and its homeostatic loop into System THREE. System FIVE is responsible for establishing the identity and purpose of the organisation. Typical responsibilities of System FIVE are establishing the vision, mission and strategic goals of the organisation but this is to be done in collaboration with System FOUR (Ríos, 2012, p. 46).

"System FIVE within service governance cannot be elite; it is to be the embodiment of the values of the other services and services systems themselves." (Beer, 1972)

"System FIVE's function is to balance the present and future of the organisation, bearing in mind both the internal and external aspects affecting it. It is responsible for establishing the "identity" of the organisation, that is to say, defining what it is or what it wants to be and also what "is not or does not want to be". Such distinctions are also important when it comes to making it clear what the limits of the organisation are, in other words, fixing the boundaries between what forms part of the environment and what represents the organisation. Implicit in this is the establishing of the values, norms and rules of conduct that should prevail and impregnate the organisation at all its recursion levels, namely, its "ethos". These will facilitate the cohesion of the whole set. Typical responsibilities of System FIVE are those determining the vision, mission and strategic goals of the organisation. The type of management it must provide is "Normative Management", unlike the "Strategic Management" exercised by System FOUR (with the contribution of System THREE) and the "Operative Management" specific to System THREE."(Ríos, 2012, p. 46).

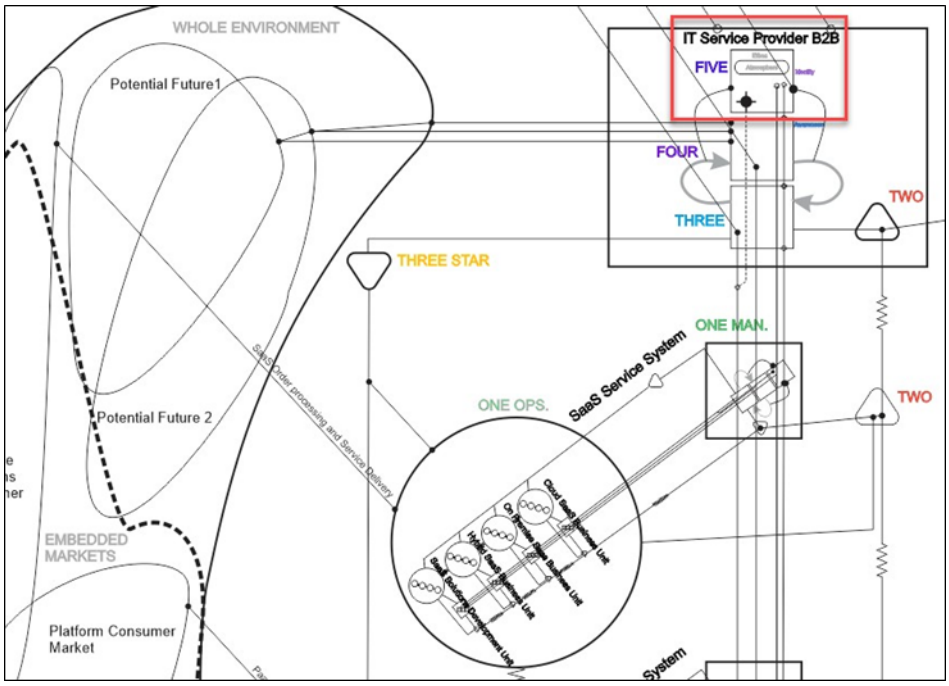


Figure 28: Viable System FIVE Design of the IT Service Provider B2B

Design recommendations proposed regarding System 3 Design:

- System FIVE, which consist of executive leadership, must build relationships with relevant metasystem in Industry.

- System FIVE must continuously have a full appreciation of the service system variety and be aware of any residual variety detected by System FOUR. This allows System FIVE to implement the required coalition policies while maintaining the Service Systems identity.

- System FIVE must understand the Industry treads and current affair along with global affairs that could impact on the service system.

- System FIVE must establish norms and governance rules that are clearly communicated to all service subsystems.

- System FIVE must always be attuned with global market dynamics, technological development and economic environment through the most reliable sources available.
- System FIVE must introduce new ethos and identity into a business through governance

mechanisms.

The next section discussed the developed Systemic Continuous Complexity Management Process for designing viable service systems.

6.4 Proposed Systemic Continuous Complexity Management Processes for Designing Viable Service Systems

In applying the ISSM, this study has established a complexity management processes required such that residual complexity can be dealt which upon detection or discovery in a continuous process. Service system redesign initiatives are introduced and executed with care to avoid introducing too many changes that can retrospectively affect current system performance. The entire continuous complexity management approach to designing a viable service system can be seen in Appendix O – Conceptual Process for Service System Complexity Management. The next subsections discuss portions of the process in more detail.

6.4.1 Collaborative Definition of Service System such that VE can be conducted

The process of service system complexity management begins with defining the service using the triple embedment, adhering to the laws of viability, as seen in Figure 29. Systems are to be defined as viable units at all levels of recursions and embedments. Selecting the correct triple recursion is crucial and recommended to be done with input from executive leadership and multidisciplinary viewpoints. Having defined the system and its definition of viability an abstract state machine, 'black box' definition of the service system established.

VE provides feedback to the system definition to ensure that a viable system definition is reviewed as soon as residual variety is detected. This is important as it provides a platform which service system management can use to be kept current with the systems residual variety while implementing redesigns.

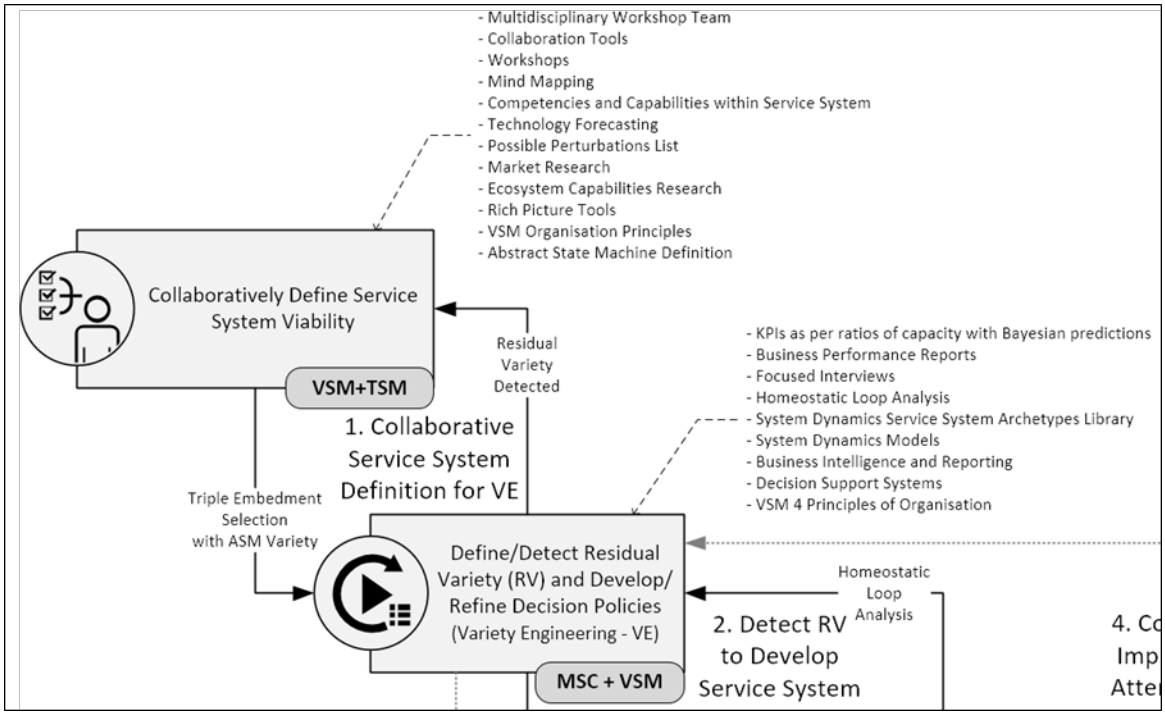


Figure 29: Collaborative Service System Definition for VE

Next, we look at how the definition of the service system progresses to VE.

6.4.2 Collaborative Definition of Service System such that VE can be conducted

VE is done with two objectives. The first is to analyse the system in focus for residual variety and the second it's to improve proactive detection of residual variety. Systems and processes are put in place to ensure an adequate response to detected residual variety, as presented in Figure 30. Decision policies are refined to incorporate conditions for initiating service or service system redesigns or decommissioning versus service or service system improvement.

There is a feedback from the redesign stage in the form of homeostatic loop analysis chart to implement criteria of homeostasis and detection of residual variety. A service system or service redesign is to initiate service system and service KPIs redefinition. This ensures that homeostasis maintains relevance with market and internal service system capability.

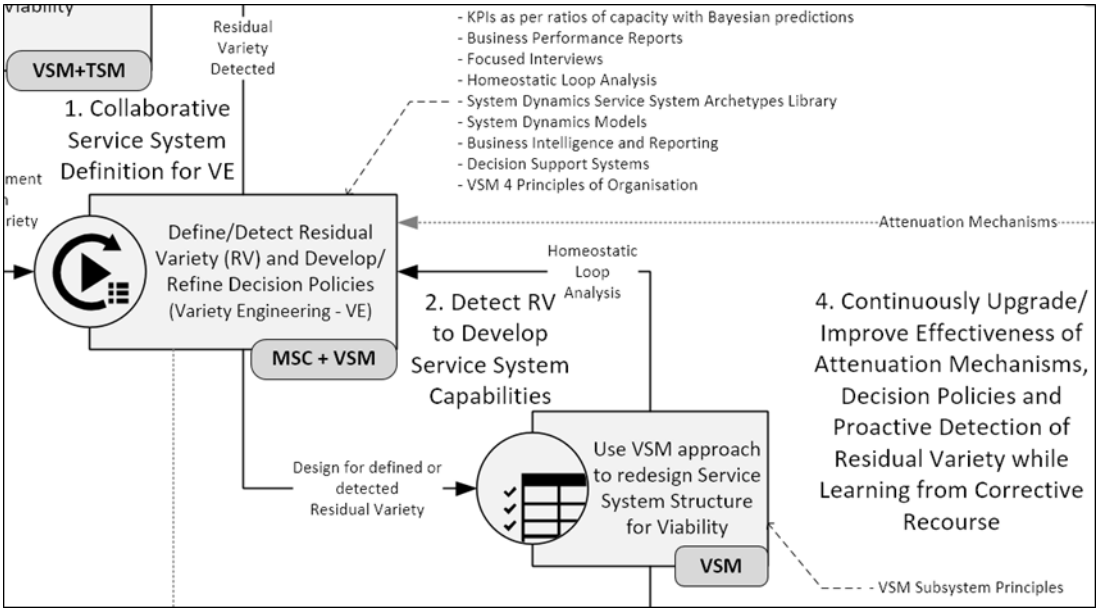


Figure 30: Detecting Residual Variety to Develop Service System Capabilities

Next, we look at service system designs can are implemented without inducing variety into the services system.

6.4.3 Implementing Service System Designs without introducing Self-Induced Variety

Once residual variety is detected, the VSM is used to redesign the service system and if required redefine the services to be delivered. VSM charts and with Quality Function Deployment Matrices, if preferred, are utilised to 'blueprint' the service system to project teams that are to implement the new service system and services as in Figure 31. Concurrently amplification and attenuation mechanisms are established to coordinate implementation activities while ensuring that there is no self-induced variety during execution.

Feedback mechanisms are put in place to update system variety during implementation not only to the ends of co-ordinating system implementation but to capture learnings and possibly influence the redesign of the service system or redefine the services while in implementation. This allows adoption while implementing service system redesigns.

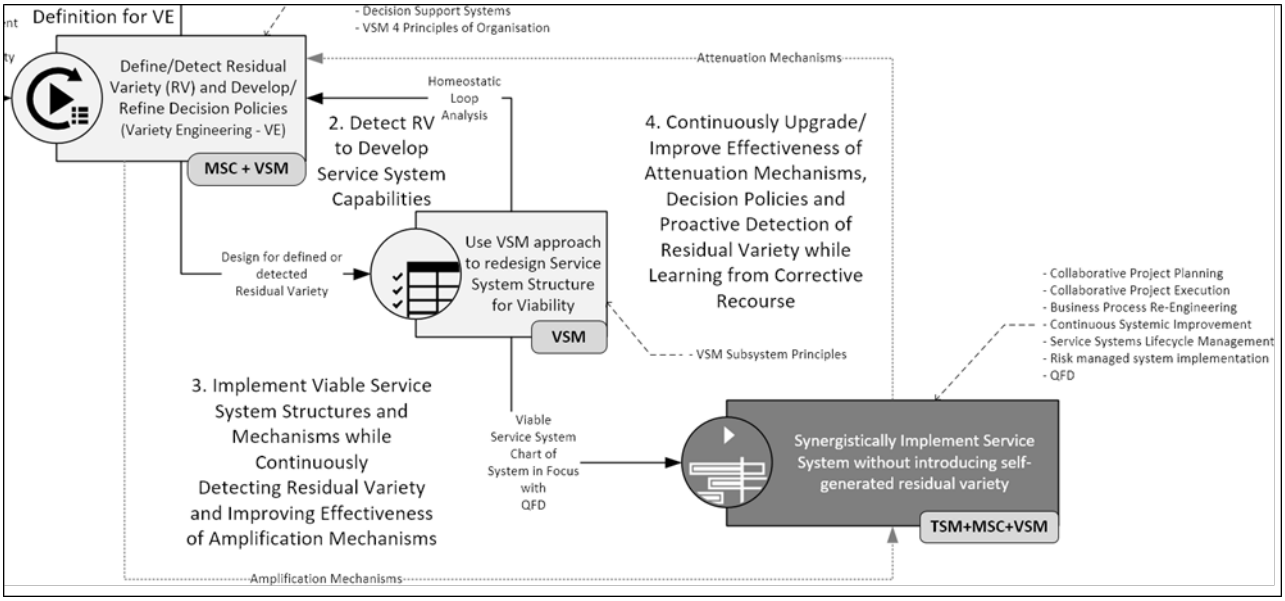


Figure 31: Synergistically Implementation without Self-Induced Variety

This chapter has discussed the proposed Systematic Continuous Complexity Management process that can be applied to ensure that there is continuous complexity management. The finding is that the feedback mechanisms between each process are essential in ensuring that unintended residual variety is not introduced into the service system while implementing a viable service system redesigns. From this, it has been noted that careful consideration needs to be taken in both the design process and the implementation process of viable service systems.

The next chapter contains the conclusions made from this research and highlights further research opportunities in light of the research findings.

6.5 Managerial Implications of the Study

The proposed Systemic Continuous Complexity Management Processes for Designing Viable Service Systems derived from applying The Integrated Service System Model (ISSM) has several managerial implications. In particular, the role of business and service system designers and managers is crucial for this model to work, from communication methods to the problem-solving tools used to drive collaborative participation. Furthermore, their understanding of the business and its environments is vital to the success or failure of the model. Business and service systems managers must adopt a new language and approach for communicating service system complexity

such that the correct internal business structures and mechanisms are designed and implemented to tackle residual variety. Such an approach provides a unified systemic 'black box' abstract state machine definition, as in Figure 22, of the various service systems within the business providing a common language to communicate system complexities and capabilities required to manage and operate service systems.

Having provided a unified definition of the service system in all its variety, the business then embarks on a variety engineering exercise consisting of multidisciplinary teams. The benefits of multidisciplinary approaches have always been evident to business, but the challenge becomes a regular communication and an analysis framework to adopt. The 'complexity' taxonomy and ontology provide a common framework from which a multidisciplinary team can recommend different service system designs. For example, in this research, the 'black box' definition of the service system was consistent all through executive leadership level, to customers, to partners and to internal service engineers. Such a unified service system definition provided a standard of what customers expect from the IT service system customers. Alternative service system designs are evaluated against the desired service system definition for residual variety. This is very useful when reviewing enterprise architecture, current state and desired future state.

The Viable Systems Model provides the minimal structure to achieving viability which is fundamental to addressing business accountabilities and responsibilities in a services-oriented business model that is to survive in a dynamic market environment. Service system managers and service system designers need to thoroughly appreciate and understand the VSM, its cybernetics principles and how it is applied to deliver viable service systems. Furthermore, the VSM approach requires that amplification and attenuation mechanisms are implemented to manage the variety between the management system and the managed system. This is particularly important and implies that service system managers must contribute to technologies being used in the business.

Service system managers are to be involved in technology forecasting, and strategic technology decisions for the business in consideration of complexity management mechanisms and complexity-management-oriented performance metrics. Reporting systems and decision support systems must cater for all the variety in the information required to operate and manage and viable service system. Business managers will have to consider information technologies that allow for the timely market and environment insights that will drive continuous business internal business structures

adaption and new performance metrics adoption. This is a paradigm shift from the traditional internal capability improvement orientation of competencies to one of an external complexity-reducing value proposition. Market dynamics, socio-economic dynamics, environmental dynamics and value co-creation dynamics are considered in the latter.

In this model, management, particularly business and service managers, need to be highly involved throughout the entire lifecycle of the service system from design to dissolution or decommission. Management must apply Organisational Cybernetics principles in designing and managing service system to achieve services and business viability.

7. CONCLUSION AND RECOMMENDATIONS

This study has stressed the need for a service system design framework or model that considers value co-creation complexities under dynamic market environments. To this end, two research objectives were set; to determine the state of viability in current service systems in SA and to provide a conceptual design for viable IT service systems in South Africa.

The first research objective has been addressed in this manner. The study has demonstrated the use of VE and ASM for analysing and quantifying residual variety in IT service systems. Current IT service systems were found to contain a residual variety. The findings are that the ASM is a reliable method for quantifying variety through defining system states and using excel and a mind mapping tool, variety engineering can be conducted reliably. Incorporating capabilities and perturbations into ASM as state transitions highlights system stated that would not be considered. This produces a reliable method to appreciating service system variety and identifying the residual variety.

The second research objective has been addressed in this manner. The ISSM is proposed as a conceptual model to approach the designing of service systems. The model integrates the VSM, the MSC and the TSM along with the analysis tools VE, SD models and ASM to produce viable service system design artefacts. Contained in the artefacts are design elements for a viable IT service system considering both value co-creation and market dynamics. The findings are that in redesigning the service system, multidisciplinary participants are engaged and this has proven to be a necessary approach for producing viable service system designs. This is facilitated through workshops and focused interviews which involved training the participants on systems theory, systems thinking, the VSM and other cybernetic models. In redesigning the services systems using the proposed ISSM the other finding is that there are three crucial systemic capabilities that need to be designed into a viable services system, namely: (1) The ability to effectively detect residual complexity presented by the market; (2) The ability to translate the detected residual variety into viable system re-designs and; (3) The ability to implement the produced system designs without inducing unintended residual variety.

The research question asks for the most relevant determinants in designing viable IT service systems for the digitally transforming IT industry of South Africa. This is answers in the form of three systemic capabilities, discovered through the application of the proposed ISSM. Having found

existing models and frameworks in the literature lacking a holistic solution, the study argued that the proposed conceptual ISSM presents a systematic iterative process which can be utilised to diagnose, design and manage viable service systems. The proposed model has management implication mainly that service managers are extensively involved and multidisciplined complexity management principles are applied.

7.1 Limitations

This research is limited to the currently operating service systems within a VAD in South Africa. The research is limited to this degree in providing viable service system designs within the South African context. As such, the research does not investigate elements beyond the discussion issues provided by the firm participants.

7.2 Suggestions for further research

It is hoped that future research will demystify the use of the cybernetic models underpinning the approach and assists in designing service-oriented organisation of any type. Although the model developed in this study is applied to IT service system, it should be tested by applying the model to other types of service systems that exist in the industry.

Another important consideration is that the Integrated Service System Model is applied in the study in an environment with an existing service system. Further research is proposed in the design of service systems from service system inception. Research is proposed to assess how the determinants of service system viability change over the entire lifecycle of service, how the model can be adapted to the sustainable management of innovation within organisations and how the model tackles environments that are profoundly impacted by innovation under difficult entry to markets conditions, such as in tech start-ups.

Further research is proposed to apply the developed Integrated Service System Model to other service systems in the industry with market dynamics that require intelligent adaptive organisation. Further research is also proposed to investigate other industry areas where such design approaches are applicable, such as adaptive cloud computing, artificial intelligence, integrated intelligent cities, government and public services, to name a few.

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Appendix A – IT Service System Configurations to Consider

Table 7: PaaS Service System Configurations

IT service system configuration	Service Type	Vendor	ISV	IT Services Aggregation Platform	Consumer	Supporting from other Service Systems Resources	Service Example
PaaS Service System Configuration 1	PaaS	Yes			Yes		Microsoft Azure (App Services)
PaaS Service System Configuration 2		Yes		Yes	Yes		
PaaS Service System Configuration 3		Yes		Yes	Yes		
PaaS Service System Configuration 4		Yes	Yes	Yes	Yes		
PaaS Service System Configuration 5		Yes			Yes	Yes	
PaaS Service System Configuration 6		Yes		Yes	Yes	Yes	
PaaS Service System Configuration 7		Yes		Yes	Yes	Yes	
PaaS Service System Configuration 8		Yes	Yes	Yes	Yes	Yes	

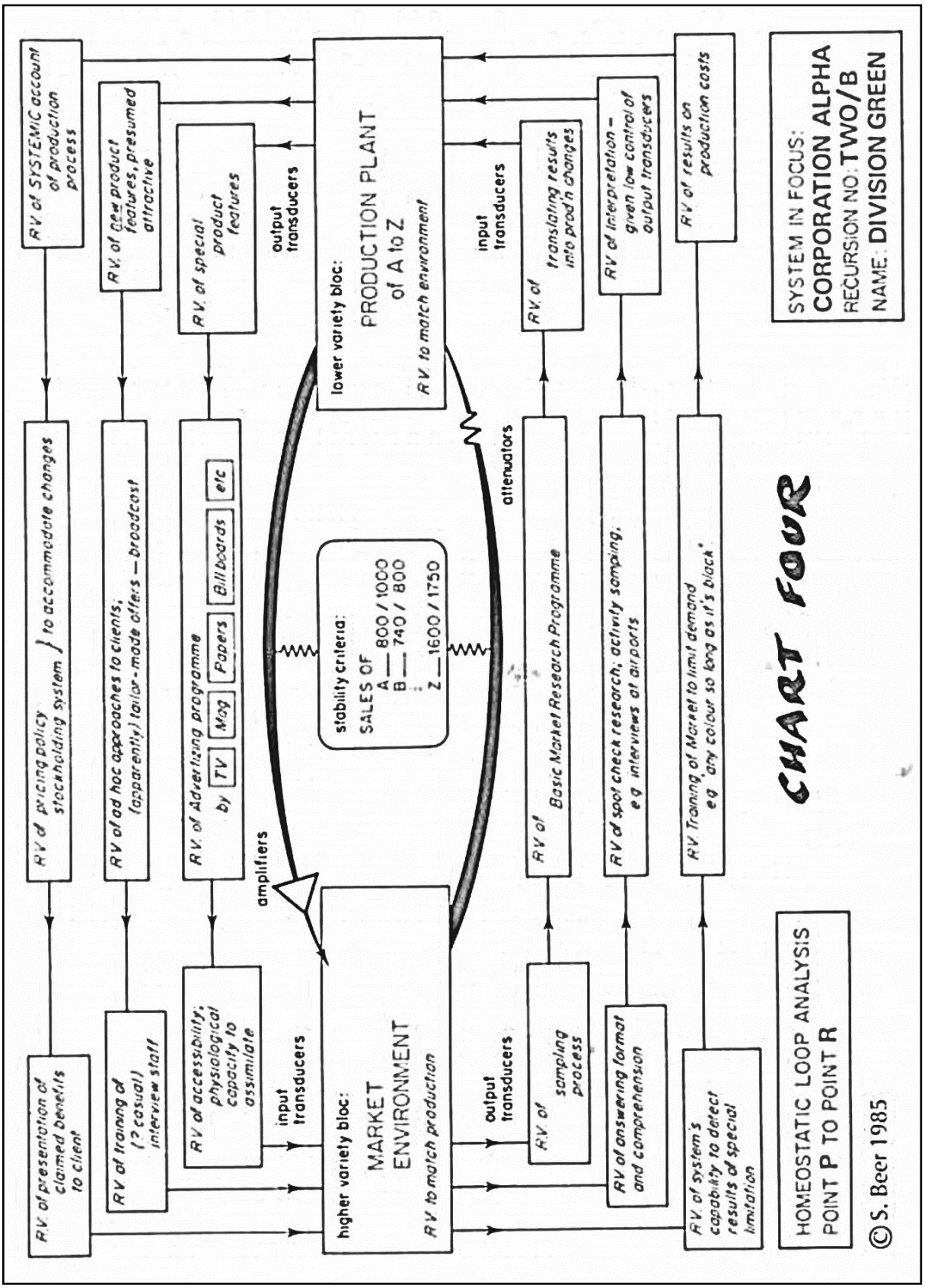
Table 8: IaaS Service System Configurations

IT service system configuration	Service Type	Vendor	ISV	IT Services Aggregation Platform	Consumer	Supporting from other Service Systems Resources	Service Example
IaaS Service System Configuration 1	IaaS	Yes			Yes		Microsoft Azure (Virtual Machines)
IaaS Service System Configuration 2		Yes		Yes	Yes		
IaaS Service System Configuration 3		Yes		Yes	Yes		
IaaS Service System Configuration 4		Yes	Yes	Yes	Yes		
IaaS Service System Configuration 5		Yes			Yes	Yes	
IaaS Service System Configuration 6		Yes		Yes	Yes	Yes	
IaaS Service System Configuration 7		Yes		Yes	Yes	Yes	
IaaS Service System Configuration 8		Yes	Yes	Yes	Yes	Yes	

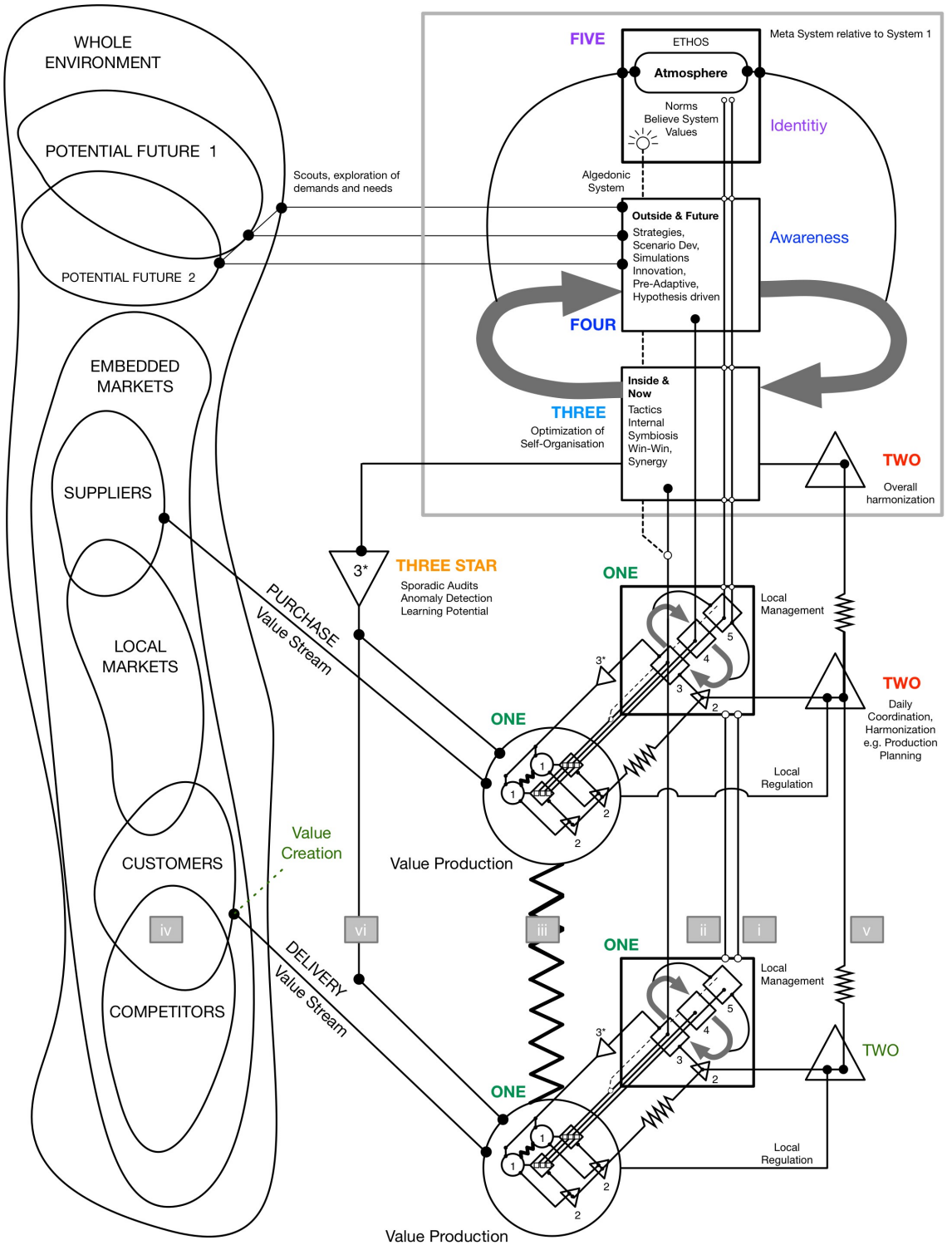
Table 9: ITaaS Service System Configurations

IT service system configuration	Service Type	Vendor	ISV	IT Services Aggregation Platform	Consumer	Supporting from other Service Systems Resources	Service Example
ITaaS Service System Configuration 1	ITaaS	Yes			Yes		Hybrid IT infrastructure Management
ITaaS Service System Configuration 2		Yes		Yes	Yes		
ITaaS Service System Configuration 3		Yes		Yes	Yes		
ITaaS Service System Configuration 4		Yes	Yes	Yes	Yes		
ITaaS Service System Configuration 5		Yes			Yes	Yes	
ITaaS Service System Configuration 6		Yes		Yes	Yes	Yes	
ITaaS Service System Configuration 7		Yes		Yes	Yes	Yes	
ITaaS Service System Configuration 8		Yes	Yes	Yes	Yes	Yes	

Appendix B – Example of a Complete Homeostatic Loop Analysis



Appendix C – Example of a Complete Viable System Model Chart



Viable System Model

Stafford Beer

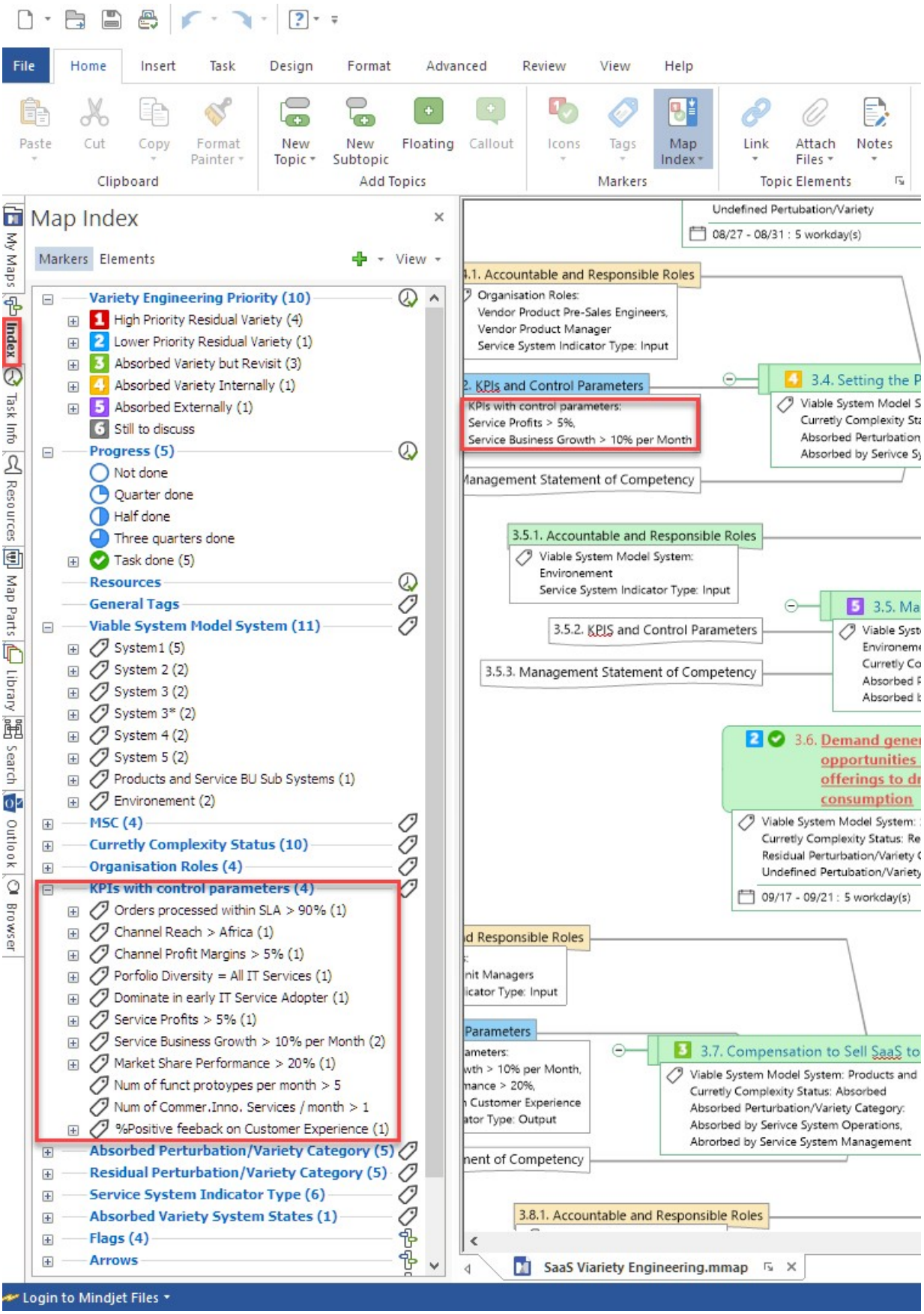
Transducer

Each ● represents an interface between each subsystem

Channels:

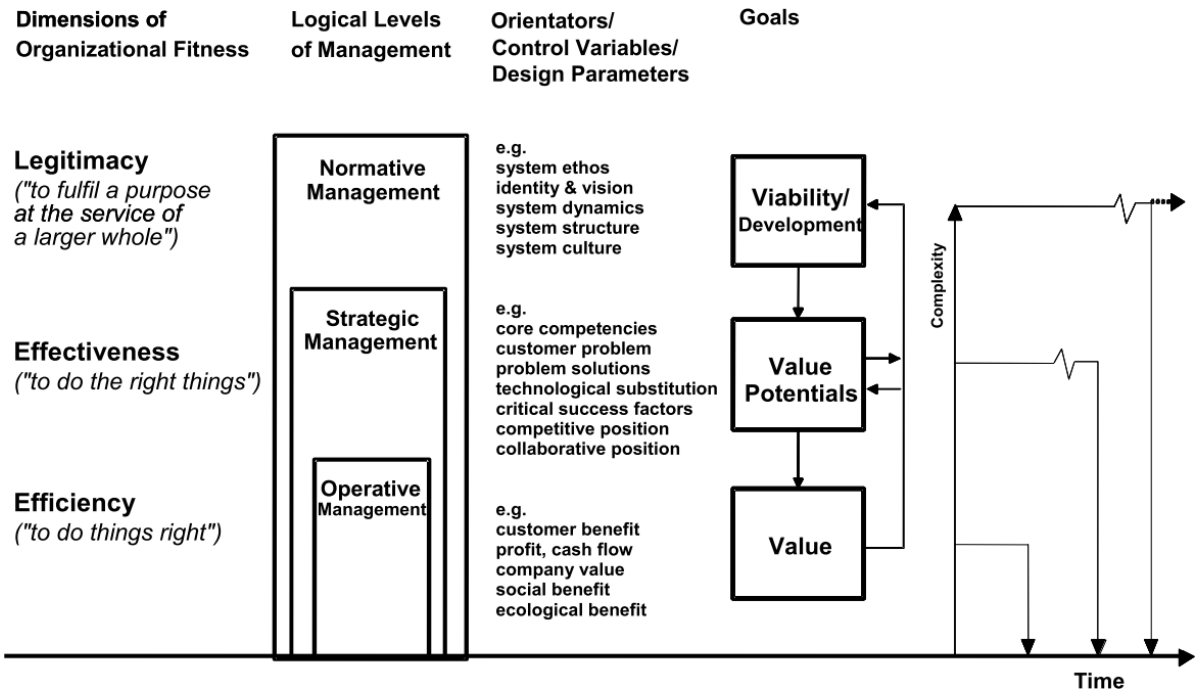
i Interventions & Rules
ii Ressource Bargain
iii Operational Linkages
iv Overlapping Sub-Environments
v Anti-Oscillation, autonomous
vi Sporadic Audits

Appendix D – Mindjet MindManager Map with Classifications and Indexes

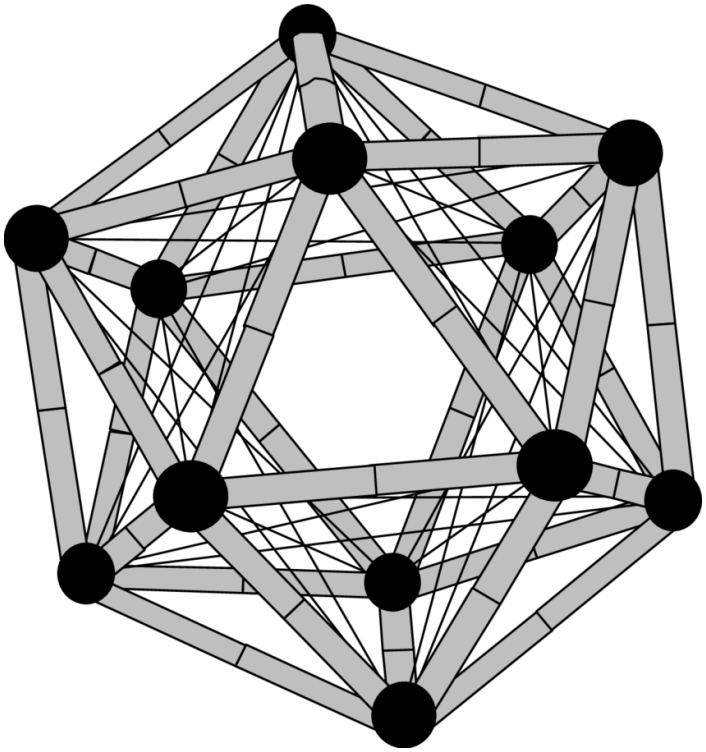


Appendix E – Other Cybernetic Models to be used with VSM

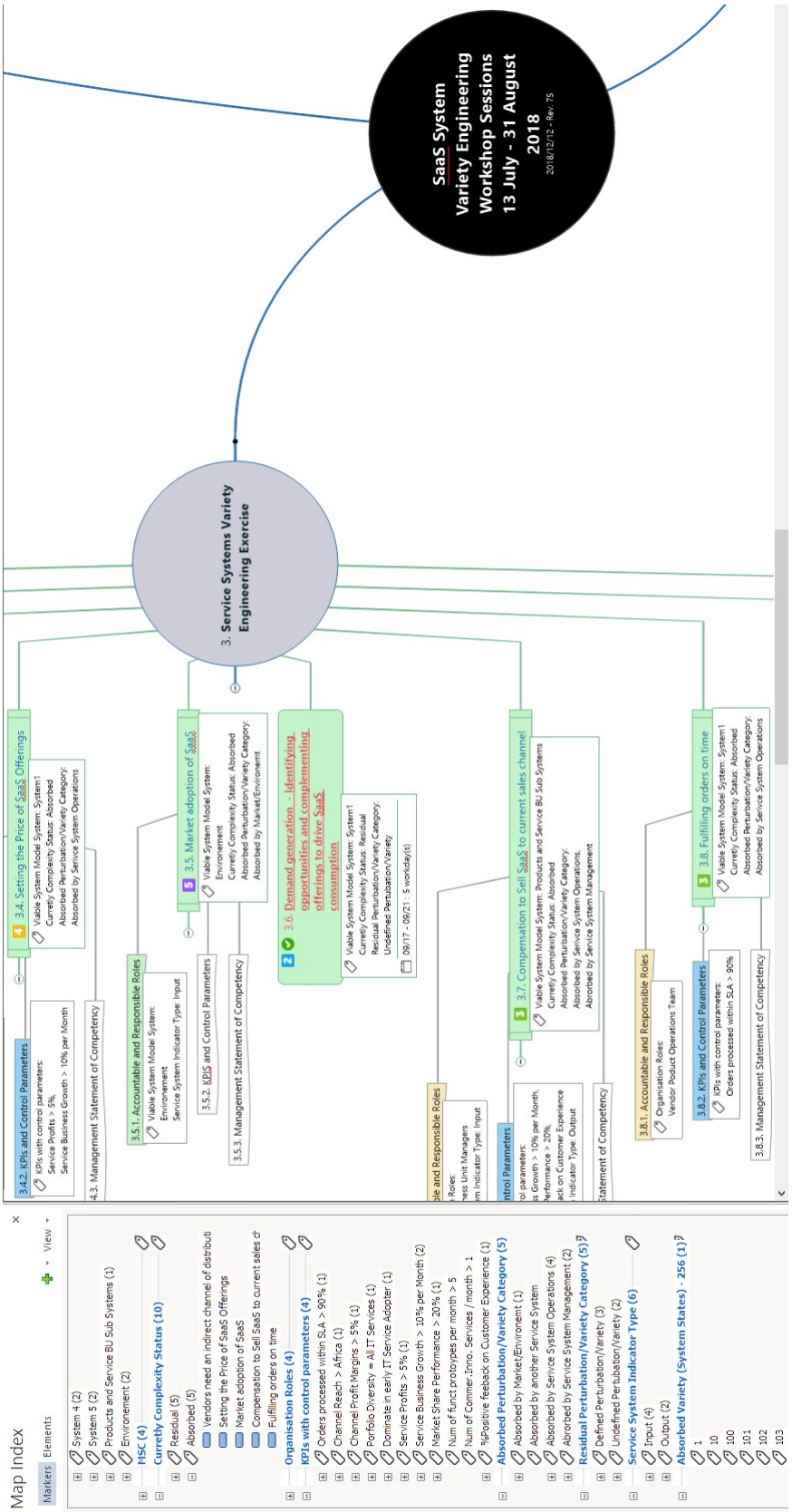
Model of Systemic Control



The Team Syntegrity Model with the Vertices representing Problems to be solved and the connectors are Team Members



Appendix F – Example of mind map captures during Interdisciplinary Workshop Sessions



Appendix G – Questionnaire used on focused interviews on assessing Capabilities and Competencies in IT Service Business Units and Departments

Interview: Internal Capability and Competency Assessment

Question 1
Please state your role and responsibilties in the organisation

Question 2
What IT services do you offer?

Question 3
What roles do you have in your team or departmen to support these services?

Question 4
What the KPAs/KPIs you report to deliver these service and how frequetly do you provide these reports to business?

Question 5
What SLAs are in place and are they clearly understood and complied to by all team members?

Question 6
Do you have documented standardised processes and procedures?

Question 7
Please provide documented processes, procedures and reports you provide to business.

Question 8
What are the challenges that you face in delivering these services

Question 9
Are you aware of any competitors/disruptors in your market?

Question 10
If so, what has been put in place to ensure market security?

Appendix H – Focused Interview Questionnaire for Service System Perturbations

Interview: Service Systems Perturbations

Question 1

Please state your role and responsibilities in the organisation.

Question 2

For which IT services do you provide support for?

Question 3

What roles do you have in your support team?

Question 4

What are the KPAs and KPIs that you report on back to your service management team and how frequently do you provide reports to them?

Question 5

Please provide the reports you provide to management

Question 6

What are the SLAs applicable to you?

Question 7

Are there challenges that you endure to support these services?

Question 8

Is there a documented process for handling new ticket types/new cases?

Question 9

Are there continuous improvement feedback mechanisms to improve service delivery?

Question 10

Are there Change Management processes in place to tackle new system changes?

Question 11

Please provide documented change management procedures.

Appendix I – Focused Interview Questionnaire for Service System Dynamics

Workshop: The purpose of the workshop is to understand the service system dynamics

Question 1

What are the capacities and throughput of your service system?

Question 2

How do delays and delays and feedback loops impact on your service levels?

Question 3

What are the bottlenecks in your processes?

Question 4

What amplification and attenuation mechanisms do you apply in your processes and procedures?

Question 5

What changes are required to meet current and future demands for the services you provide?

Appendix J – Focused Interview Questionnaire for Service System Capability

Interview: Internal Capability and Competency Assessment

Date: 18 October 2018 Interviewee: Executive for Vendor

Question 1

Please state your role and responsibilities in the organisation

I am the Vendor 1 Executive within Axiz running the Microsoft and Software business unit

Question 2

What IT services do you offer?

We offer Vendor 1 Cloud Service Provider (CSP) Products. This is the SaaS offering from Vendor 1, we offer this to reseller and partners to resell. We offer Traditional perpetual products like Product XXX. In my BU the other software offerings such as Product AAA and Product BBB

Question 3

What roles do you have in your team or department to support these services?

I manage the business unit. I am responsible for the growth my portfolio of products in the market and I am also responsible for the performance management of the operational within my team. I have a Vendor 1 product specialists, business development managers, product managers, and I am going to appoint a digital product manager to put more focus on our Digital Business.

Question 4

What the KPAs/KPIs you report to deliver these service and how frequently do you provide these reports to business?

Yes I provide a number of reports to business. I will share them with you but please do not distribute them. I report on revenues, profits, number of licenses sold, number of customers gained and lost in the portfolio of products. I also report on costs, mainly attached to the heads I have in my team. I have to produce quarterly reports beck to Vendor 1 on product performance in market. Microsoft will set targets on Axiz regarding having benchmarked where we should be considering why they see in the various markets around the world similar to ours.

Question 5

What SLAs are in place and are they clearly understood and complied by all team members?

I have put in place SLAs with my team to respond to their customers, internally and externally within an hour. I have to ticketing system to manage this though but I have visibility in the group mailbox. I can see what they are doing and how long it takes to respond to issues and requests. Every team member has KPAs that they have to deliver on. I review this with them quarterly unless I have an area of concern, then I can even go as far as reviewing the deliverable on a weekly basis. Like how we have the weekly meeting with the digital team around the AxizCloud Platform deliverables

Question 6

Do you have documented standardised processes and procedures?

We don't have process maps as such but we have system user manuals and detailed job description. When a new person joins us they will typically do some Microsoft training that will make them competent in providing solutions and services to market. So I send my staff to vendor training. The other reason is that we need certification to qualify to deliver certain services to market, so I get that out the way right away. Regarding internal business system the new person will shadow a current employee who is very good in that specific area for about six months. We do this because we don't want to waste time and I want the new employee to get up to speed as soon as possible. I will also provide the employee access to collaboration platforms where issues can be raised with the vendor and they can also keep up to date with current development.

Question 7

Please provide documented processes, procedures and reports you provide to the business.

I will. Please do not share externally as we would not want out competitors to get a hold of this information. The market is very competitive and everyone is interested in what everyone else is doing.

Question 8

What are the challenges that you face in delivering these services

Well, I need the cloud platform to be stable. We still have customers complaining about stupid things like buttons not working as they expect them to and seat counts not matching and so on and so forth. The weekly meeting with have with the Digital Team is documented so you have access to that. The other trend we are seeing is that customers are becoming more and more demanding because of the digital development. If they don't like something the easily move to our competitors. We are finding it harder and harder to keep our current customer. It also does not help that the support guys keep messing it up. I need them physically here so that I can
Monitor how they resolve issues. We also need better systems internally to respond faster to customer request. Maybe some automation projects are needed. Resellers want more from the AxizCloud platform too. They want us to remove all the friction in transacting. The want to be able to download transactional information as and when they please. They want is to provide them with APIs to integrate into AxizCloud. They want and end to end digital experience. They don't want to call anyone, they want to transact.

Question 9

Are you aware of any competitors/disruptors in your market?

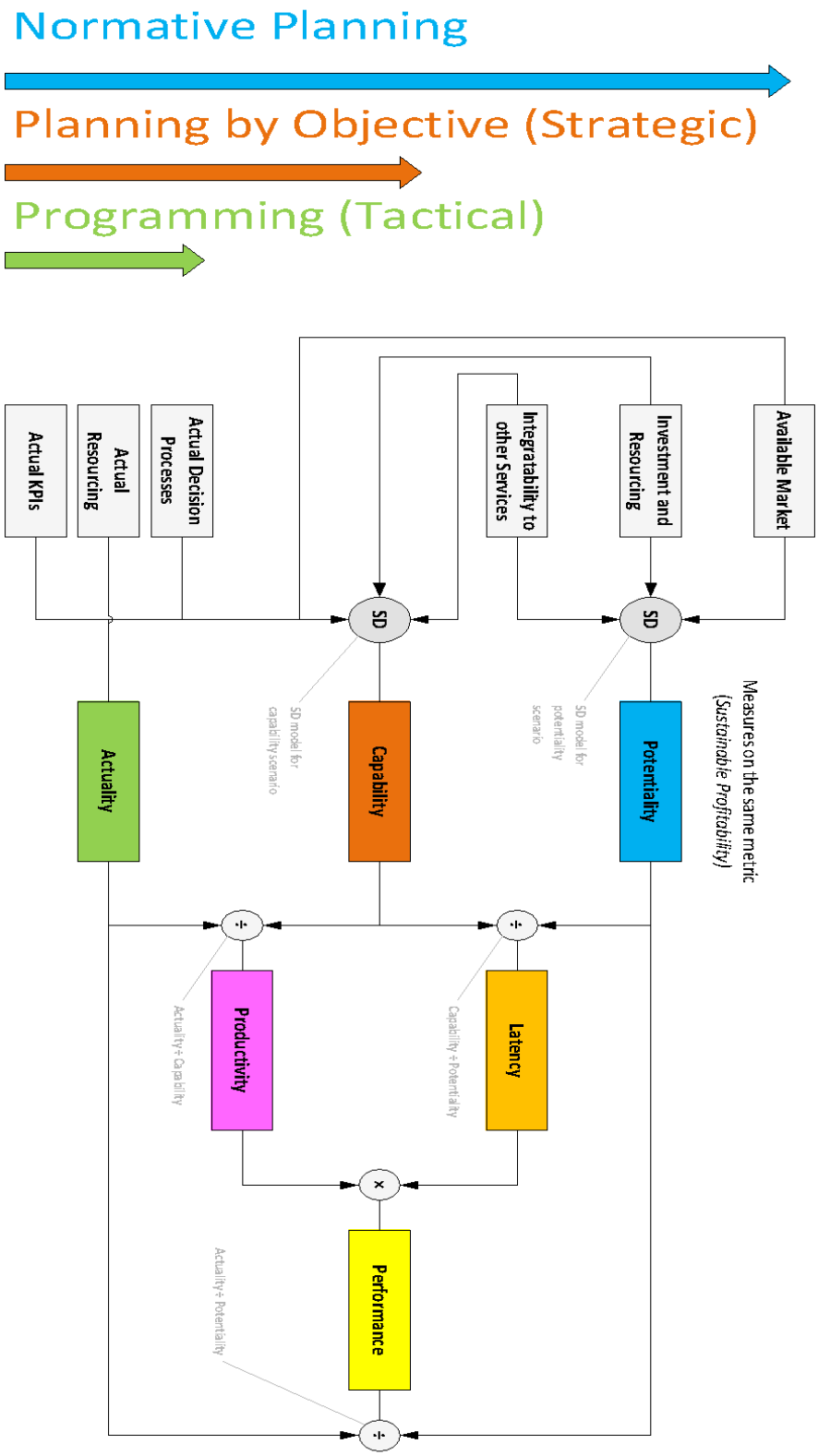
Yes. But I do not have a detailed view into our market share. Vendor 1 won't share the information with us. We have to main competitors Distributor X and Distributor Y. They are big IT distributors and they also have platforms ours. We find that we are always compared to these distributors. There are also resellers that go direct. What we see is that Vendor 1 is switching off their direct business because they see the value of the indirect model in scaling reach into regions.

Question 10

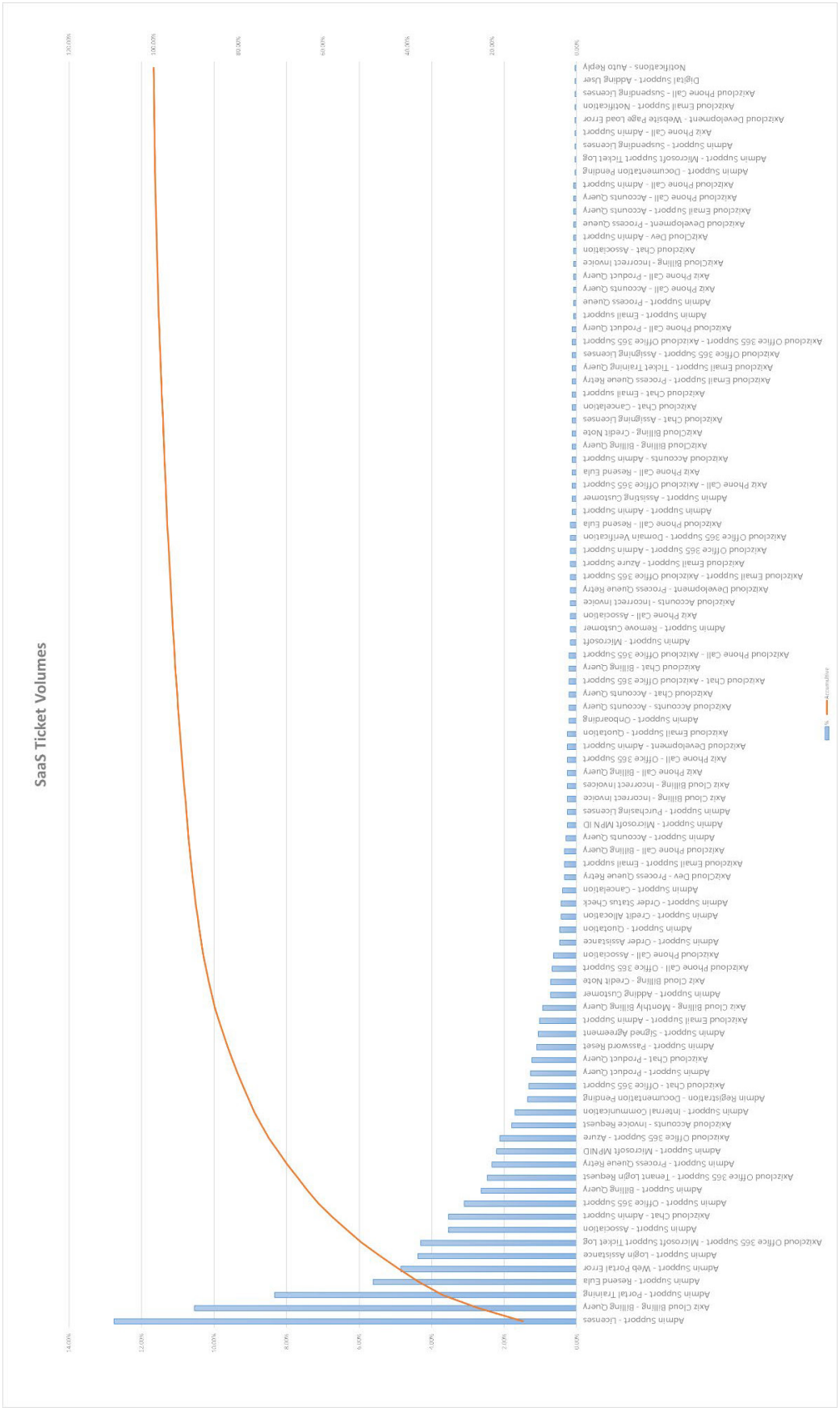
If so, what has been put in place to ensure market security?

Well so far not much, like I said, its much easier for reseller to move to other distributors that provide the same products we do. So far we don't seem to have an answer for this. We try our best to meet with the customers and convince them to stay with us. We also listen to what they want and they are becoming more are more demanding on the functionality they require on the platform. They use comments like 'Why can't you provide this to me, Distributor Z has it.'. So we need to find a fast answer to this and I don't think the solution is reactively making promises to the resellers anymore. Vendor 1 want us to focus on consumption on their IaaS and PaaS offerings. We have pretty much figured out how to do their SaaS offering. They want us to figure out how we can drive consumption in their IaaS and PaaS.

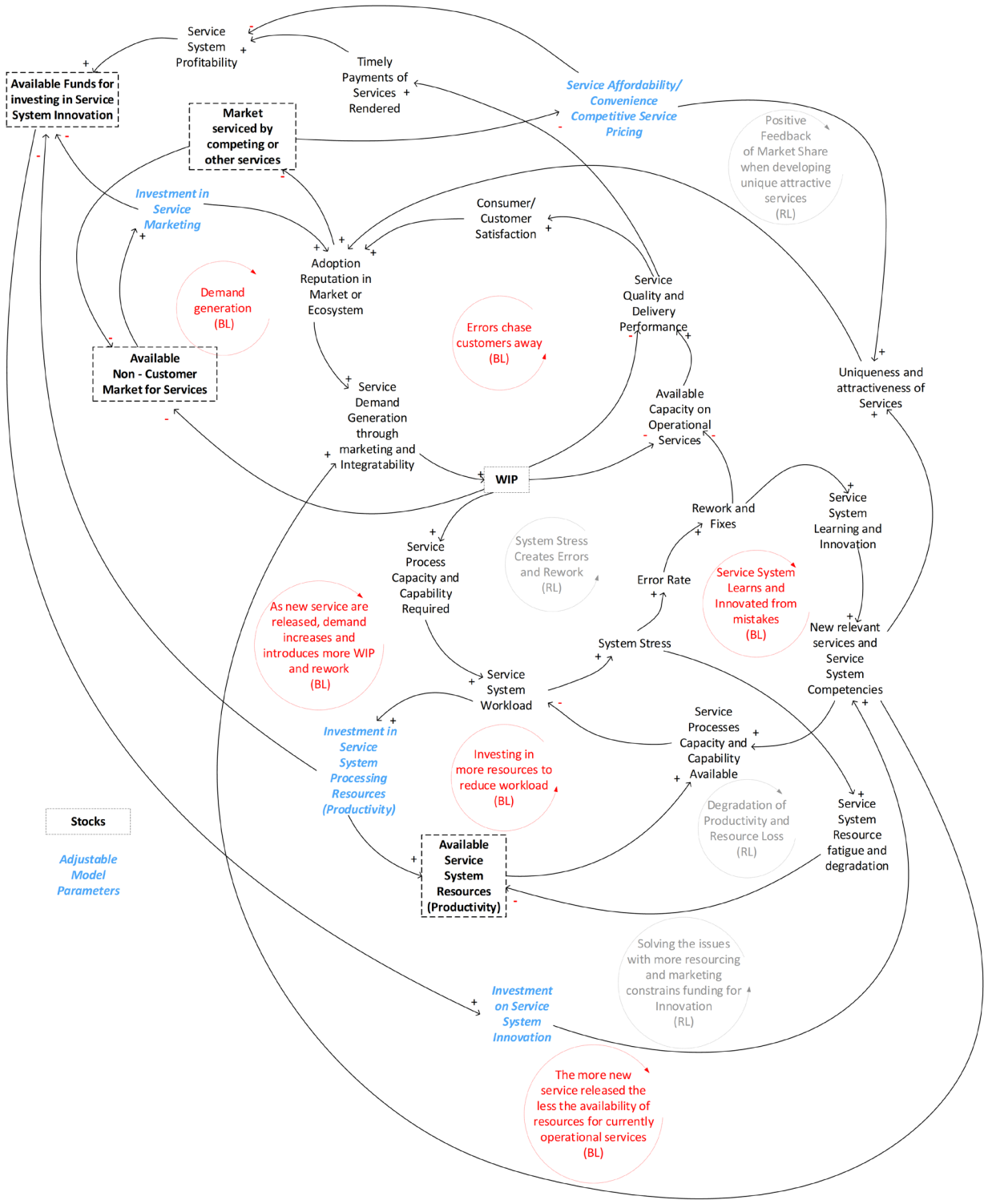
Appendix K – IT Service System Model of Systemic Control



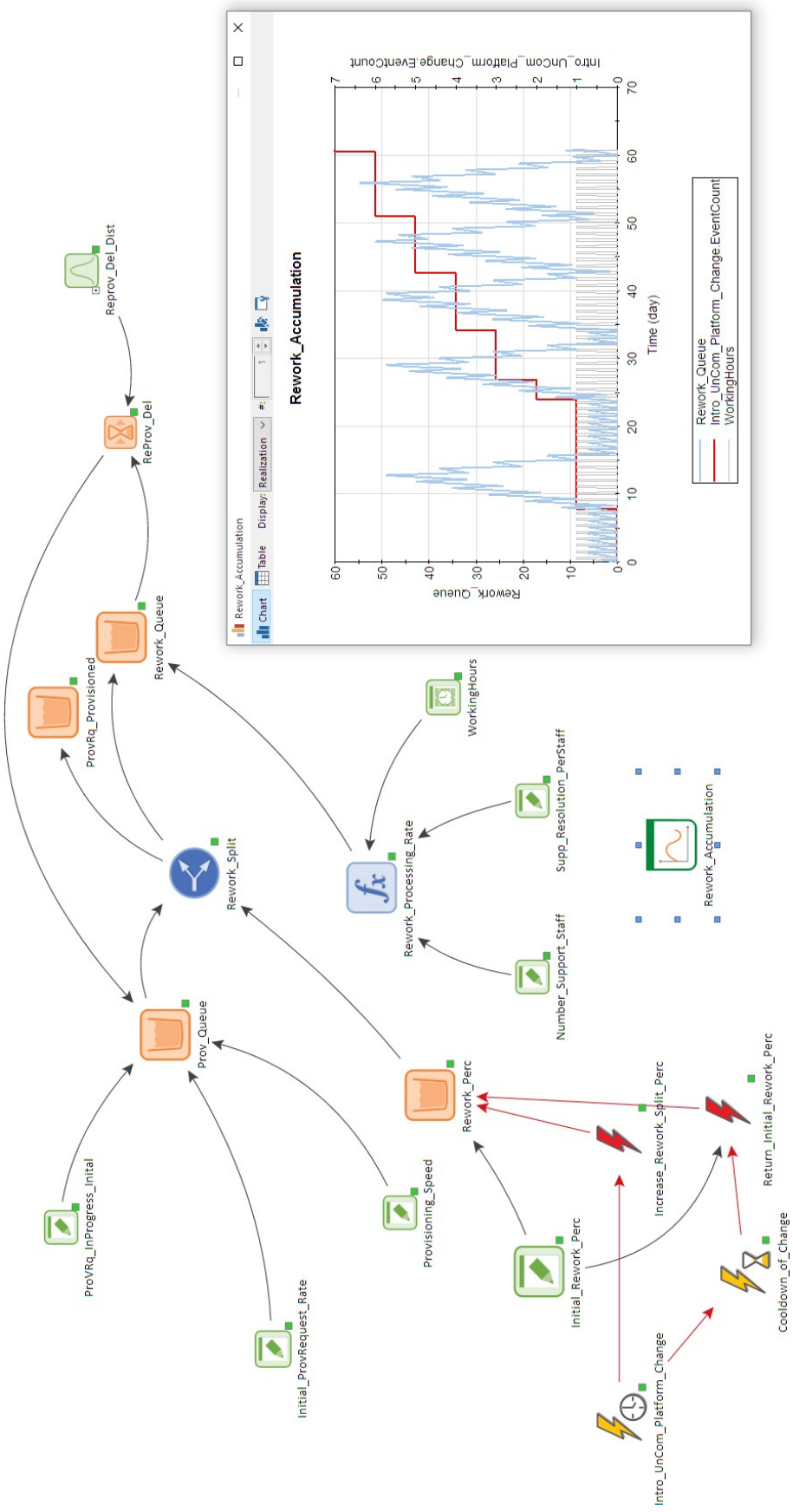
Appendix L – SaaS Service System Support Ticket Volume Contributions



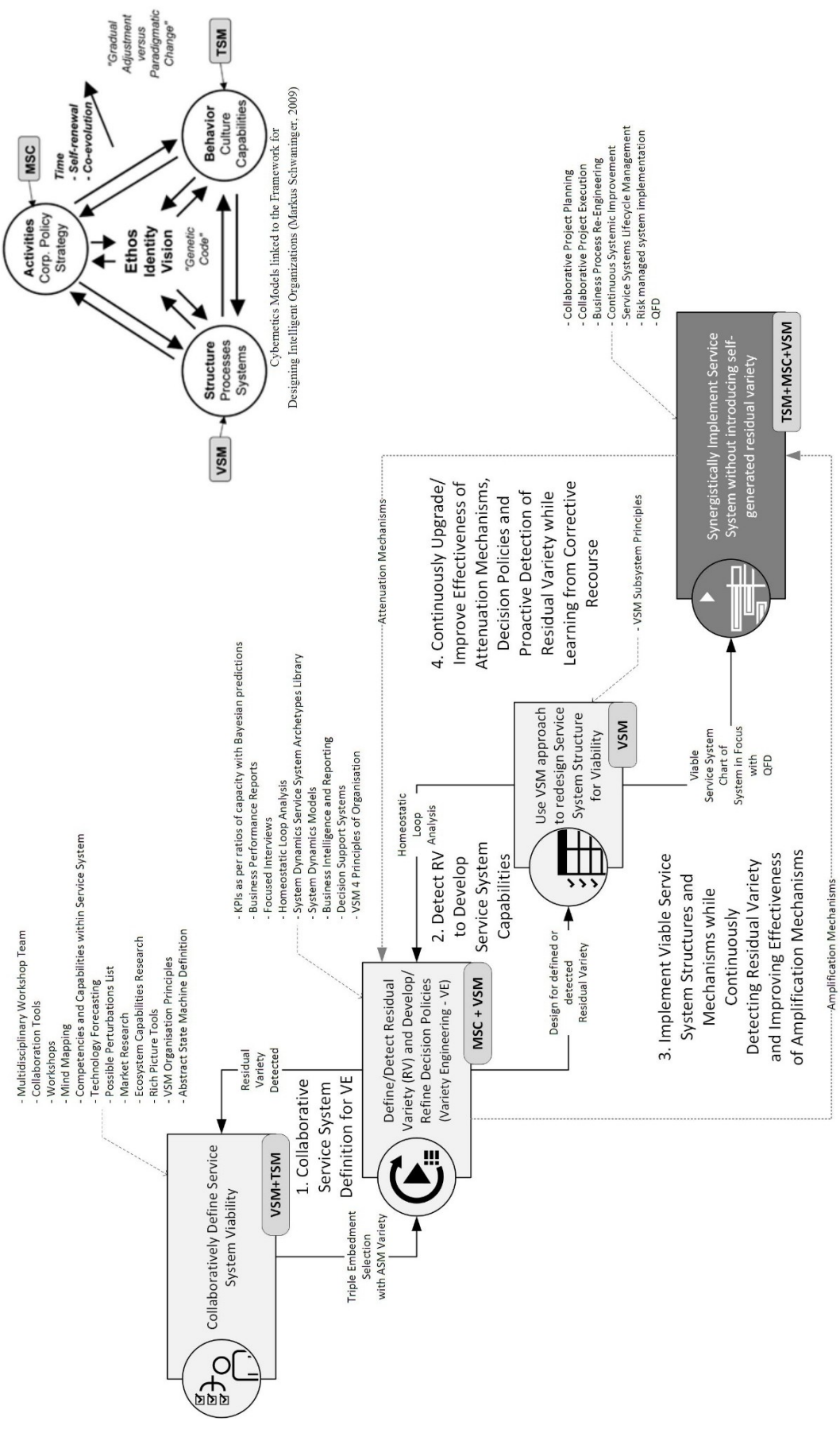
Appendix M – Service System Causal Loop Diagram (CLD)



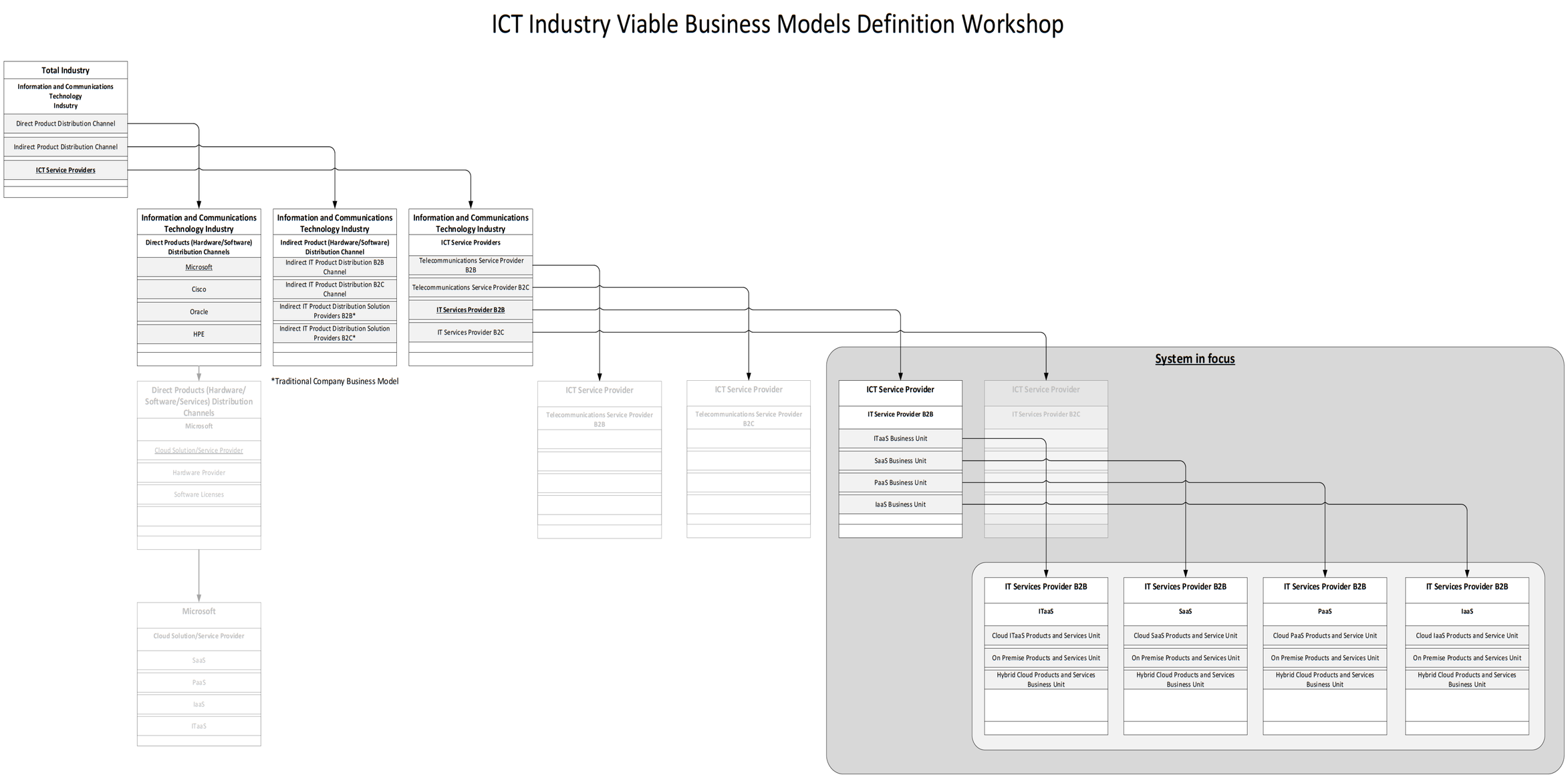
Appendix N – Service System SD Model



Appendix O – Conceptual Process for Service System Complexity Management



Appendix P – IT Service System Triple Embedment

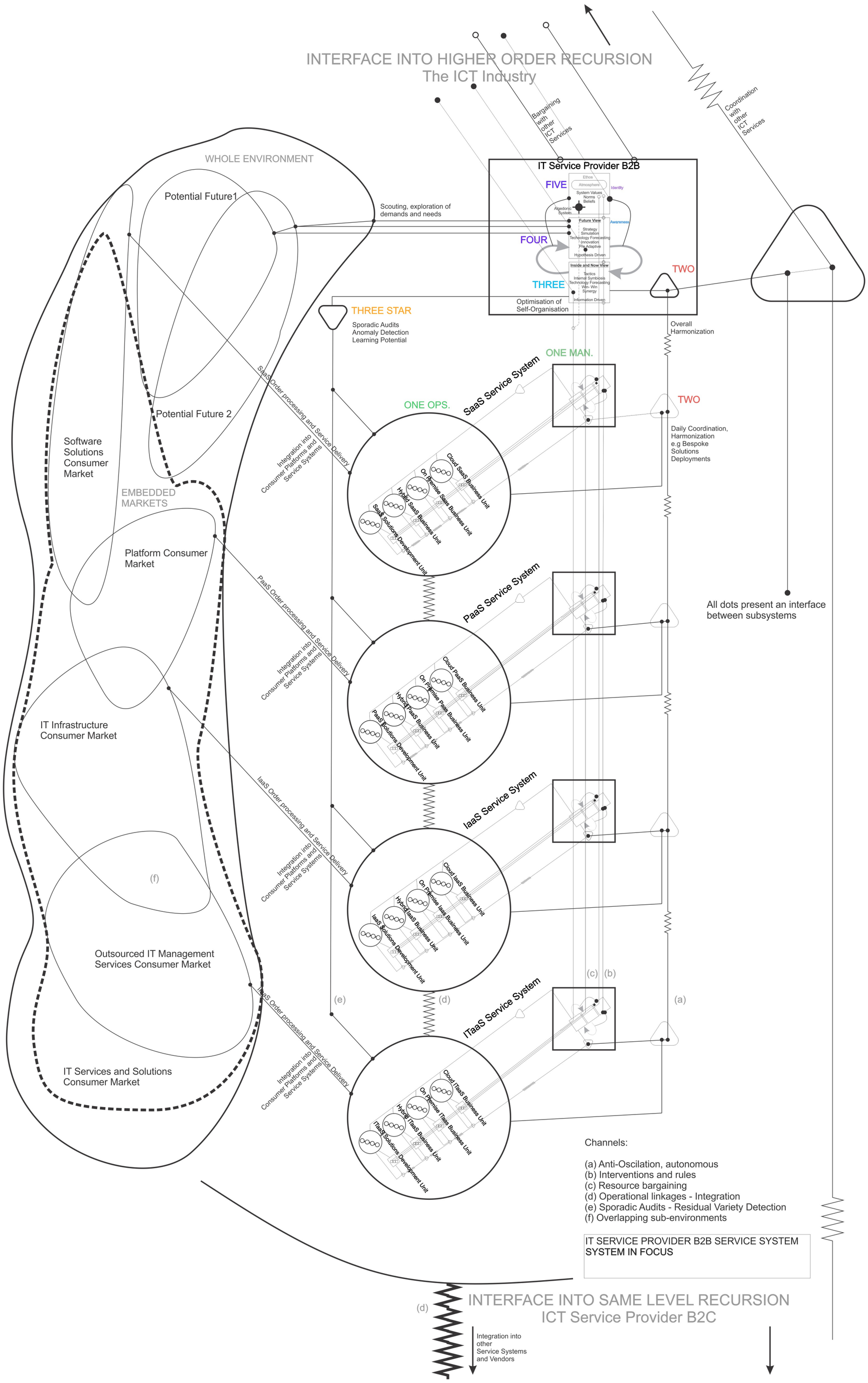


Appendix Q – Service System States

Service System States					Cybernetic System Definition				
	Inputs			Outputs					
System State	Integratability to other services (S,T)	Adequate investment and resourcing (S,T)	Available Market (S,T)	Profitability (S,T)	Integrability System State Definition	Adequate Investment System State Definition	Market Availability System State Definition	Sustainable Profitability System State Definition	Complete Service System State Definition
1	(1,1)	(1,1)	(1,1)	(1,1)	Integrability that can scale	Adequate investment	Increasing market	Profitable and improving	This service system has Integrability that can scale with Adequate investment, Increasing market and it's Profitable and improving
2	(1,1)	(1,1)	(1,1)	(0,1)	Integrability that can scale	Adequate investment	Increasing market	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment, Increasing market and it's Unprofitable but improving
3	(1,1)	(1,1)	(1,1)	(1,0)	Integrability that can scale	Adequate investment	Increasing market	Profitable but declining	This service system has Integrability that can scale with Adequate investment, Increasing market and it's Profitable but declining
4	(1,1)	(1,1)	(1,1)	(0,0)	Integrability that can scale	Adequate investment	Increasing market	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment, Increasing market and it's Un-Profitable and getting worse
5	(1,1)	(1,1)	(0,1)	(1,1)	Integrability that can scale	Adequate investment	Market share is low but improving	Profitable and improving	This service system has Integrability that can scale with Adequate investment, Market share is low but improving and it's Profitable and improving
6	(1,1)	(1,1)	(0,1)	(0,1)	Integrability that can scale	Adequate investment	Market share is low but improving	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment, Market share is low but improving and it's Unprofitable but improving
7	(1,1)	(1,1)	(0,1)	(1,0)	Integrability that can scale	Adequate investment	Market share is low but improving	Profitable but declining	This service system has Integrability that can scale with Adequate investment, Market share is low but improving and it's Profitable but declining
8	(1,1)	(1,1)	(0,1)	(0,0)	Integrability that can scale	Adequate investment	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment, Market share is low but improving and it's Un-Profitable and getting worse
9	(1,1)	(1,1)	(1,0)	(1,1)	Integrability that can scale	Adequate investment	Market that is ok but declining	Profitable and improving	This service system has Integrability that can scale with Adequate investment, Market that is ok but declining and it's Profitable and improving
10	(1,1)	(1,1)	(1,0)	(0,1)	Integrability that can scale	Adequate investment	Market that is ok but declining	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment, Market that is ok but declining and it's Unprofitable but improving
11	(1,1)	(1,1)	(1,0)	(1,0)	Integrability that can scale	Adequate investment	Market that is ok but declining	Profitable but declining	This service system has Integrability that can scale with Adequate investment, Market that is ok but declining and it's Profitable but declining
12	(1,1)	(1,1)	(1,0)	(0,0)	Integrability that can scale	Adequate investment	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment, Market that is ok but declining and it's Un-Profitable and getting worse
13	(1,1)	(1,1)	(0,0)	(1,1)	Integrability that can scale	Adequate investment	Low market availability and declining	Profitable and improving	This service system has Integrability that can scale with Adequate investment, Low market availability and declining and it's Profitable and improving
14	(1,1)	(1,1)	(0,0)	(0,1)	Integrability that can scale	Adequate investment	Low market availability and declining	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment, Low market availability and declining and it's Unprofitable but improving
15	(1,1)	(1,1)	(0,0)	(1,0)	Integrability that can scale	Adequate investment	Low market availability and declining	Profitable but declining	This service system has Integrability that can scale with Adequate investment, Low market availability and declining and it's Profitable but declining
16	(1,1)	(1,1)	(0,0)	(0,0)	Integrability that can scale	Adequate investment	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment, Low market availability and declining and it's Un-Profitable and getting worse
17	(1,1)	(0,1)	(1,1)	(1,1)	Integrability that can scale	Inadequate investment and but its incre	Increasing market	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Increasing market and it's Profitable and improving
18	(1,1)	(0,1)	(1,1)	(0,1)	Integrability that can scale	Inadequate investment and but its incre	Increasing market	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Increasing market and it's Unprofitable but improving
19	(1,1)	(0,1)	(1,1)	(1,0)	Integrability that can scale	Inadequate investment and but its incre	Increasing market	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and but its increasing, Increasing market and it's Profitable but declining
20	(1,1)	(0,1)	(1,1)	(0,0)	Integrability that can scale	Inadequate investment and but its incre	Increasing market	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and but its increasing, Increasing market and it's Un-Profitable and getting worse
21	(1,1)	(0,1)	(0,1)	(1,1)	Integrability that can scale	Inadequate investment and but its incre	Market share is low but improving	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market share is low but improving and it's Profitable and improving
22	(1,1)	(0,1)	(0,1)	(0,1)	Integrability that can scale	Inadequate investment and but its incre	Market share is low but improving	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market share is low but improving and it's Unprofitable but improving
23	(1,1)	(0,1)	(0,1)	(1,0)	Integrability that can scale	Inadequate investment and but its incre	Market share is low but improving	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market share is low but improving and it's Profitable but declining
24	(1,1)	(0,1)	(0,1)	(0,0)	Integrability that can scale	Inadequate investment and but its incre	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market share is low but improving and it's Un-Profitable and getting worse
25	(1,1)	(0,1)	(1,0)	(1,1)	Integrability that can scale	Inadequate investment and but its incre	Market that is ok but declining	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market that is ok but declining and it's Profitable and improving
26	(1,1)	(0,1)	(1,0)	(0,1)	Integrability that can scale	Inadequate investment and but its incre	Market that is ok but declining	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market that is ok but declining and it's Unprofitable but improving
27	(1,1)	(0,1)	(1,0)	(1,0)	Integrability that can scale	Inadequate investment and but its incre	Market that is ok but declining	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market that is ok but declining and it's Profitable but declining
28	(1,1)	(0,1)	(1,0)	(0,0)	Integrability that can scale	Inadequate investment and but its incre	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and but its increasing, Market that is ok but declining and it's Un-Profitable and getting worse
29	(1,1)	(0,1)	(0,0)	(1,1)	Integrability that can scale	Inadequate investment and but its incre	Low market availability and declining	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Low market availability and declining and it's Profitable and improving
30	(1,1)	(0,1)	(0,0)	(0,1)	Integrability that can scale	Inadequate investment and but its incre	Low market availability and declining	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and but its increasing, Low market availability and declining and it's Unprofitable but improving
31	(1,1)	(0,1)	(0,0)	(1,0)	Integrability that can scale	Inadequate investment and but its incre	Low market availability and declining	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and but its increasing, Low market availability and declining and it's Profitable but declining
32	(1,1)	(0,1)	(0,0)	(0,0)	Integrability that can scale	Inadequate investment and but its incre	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and but its increasing, Low market availability and declining and it's Un-Profitable and getting worse
33	(1,1)	(1,0)	(1,1)	(1,1)	Integrability that can scale	Adequate investment but reducing	Increasing market	Profitable and improving	This service system has Integrability that can scale with Adequate investment but reducing, Increasing market and it's Profitable and improving
34	(1,1)	(1,0)	(1,1)	(0,1)	Integrability that can scale	Adequate investment but reducing	Increasing market	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment but reducing, Increasing market and it's Unprofitable but improving
35	(1,1)	(1,0)	(1,1)	(1,0)	Integrability that can scale	Adequate investment but reducing	Increasing market	Profitable but declining	This service system has Integrability that can scale with Adequate investment but reducing, Increasing market and it's Profitable but declining
36	(1,1)	(1,0)	(1,1)	(0,0)	Integrability that can scale	Adequate investment but reducing	Increasing market	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment but reducing, Increasing market and it's Un-Profitable and getting worse
37	(1,1)	(1,0)	(0,1)	(1,1)	Integrability that can scale	Adequate investment but reducing	Market share is low but improving	Profitable and improving	This service system has Integrability that can scale with Adequate investment but reducing, Market share is low but improving and it's Profitable and improving
38	(1,1)	(1,0)	(0,1)	(0,1)	Integrability that can scale	Adequate investment but reducing	Market share is low but improving	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment but reducing, Market share is low but improving and it's Unprofitable but improving
39	(1,1)	(1,0)	(0,1)	(1,0)	Integrability that can scale	Adequate investment but reducing	Market share is low but improving	Profitable but declining	This service system has Integrability that can scale with Adequate investment but reducing, Market share is low but improving and it's Profitable but declining
40	(1,1)	(1,0)	(0,1)	(0,0)	Integrability that can scale	Adequate investment but reducing	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment but reducing, Market share is low but improving and it's Un-Profitable and getting worse
41	(1,1)	(1,0)	(1,0)	(1,1)	Integrability that can scale	Adequate investment but reducing	Market that is ok but declining	Profitable and improving	This service system has Integrability that can scale with Adequate investment but reducing, Market that is ok but declining and it's Profitable and improving
42	(1,1)	(1,0)	(1,0)	(0,1)	Integrability that can scale	Adequate investment but reducing	Market that is ok but declining	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment but reducing, Market that is ok but declining and it's Unprofitable but improving
43	(1,1)	(1,0)	(1,0)	(1,0)	Integrability that can scale	Adequate investment but reducing	Market that is ok but declining	Profitable but declining	This service system has Integrability that can scale with Adequate investment but reducing, Market that is ok but declining and it's Profitable but declining
44	(1,1)	(1,0)	(1,0)	(0,0)	Integrability that can scale	Adequate investment but reducing	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment but reducing, Market that is ok but declining and it's Un-Profitable and getting worse
45	(1,1)	(1,0)	(0,0)	(1,1)	Integrability that can scale	Adequate investment but reducing	Low market availability and declining	Profitable and improving	This service system has Integrability that can scale with Adequate investment but reducing, Low market availability and declining and it's Profitable and improving
46	(1,1)	(1,0)	(0,0)	(0,1)	Integrability that can scale	Adequate investment but reducing	Low market availability and declining	Unprofitable but improving	This service system has Integrability that can scale with Adequate investment but reducing, Low market availability and declining and it's Unprofitable but improving
47	(1,1)	(1,0)	(0,0)	(1,0)	Integrability that can scale	Adequate investment but reducing	Low market availability and declining	Profitable but declining	This service system has Integrability that can scale with Adequate investment but reducing, Low market availability and declining and it's Profitable but declining
48	(1,1)	(1,0)	(0,0)	(0,0)	Integrability that can scale	Adequate investment but reducing	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Adequate investment but reducing, Low market availability and declining and it's Un-Profitable and getting worse
49	(1,1)	(0,0)	(1,1)	(1,1)	Integrability that can scale	Inadequate investment and getting wor	Increasing market	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Increasing market and it's Profitable and improving
50	(1,1)	(0,0)	(1,1)	(0,1)	Integrability that can scale	Inadequate investment and getting wor	Increasing market	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Increasing market and it's Unprofitable but improving
51	(1,1)	(0,0)	(1,1)	(1,0)	Integrability that can scale	Inadequate investment and getting wor	Increasing market	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and getting worse, Increasing market and it's Profitable but declining
52	(1,1)	(0,0)	(1,1)	(0,0)	Integrability that can scale	Inadequate investment and getting wor	Increasing market	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and getting worse, Increasing market and it's Un-Profitable and getting worse
53	(1,1)	(0,0)	(0,1)	(1,1)	Integrability that can scale	Inadequate investment and getting wor	Market share is low but improving	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Market share is low but improving and it's Profitable and improving
54	(1,1)	(0,0)	(0,1)	(0,1)	Integrability that can scale	Inadequate investment and getting wor	Market share is low but improving	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Market share is low but improving and it's Unprofitable but improving
55	(1,1)	(0,0)	(0,1)	(1,0)	Integrability that can scale	Inadequate investment and getting wor	Market share is low but improving	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and getting worse, Market share is low but improving and it's Profitable but declining
56	(1,1)	(0,0)	(0,1)	(0,0)	Integrability that can scale	Inadequate investment and getting wor	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and getting worse, Market share is low but improving and it's Un-Profitable and getting worse
57	(1,1)	(0,0)	(1,0)	(1,1)	Integrability that can scale	Inadequate investment and getting wor	Market that is ok but declining	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Market that is ok but declining and it's Profitable and improving
58	(1,1)	(0,0)	(1,0)	(0,1)	Integrability that can scale	Inadequate investment and getting wor	Market that is ok but declining	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Market that is ok but declining and it's Unprofitable but improving
59	(1,1)	(0,0)	(1,0)	(1,0)	Integrability that can scale	Inadequate investment and getting wor	Market that is ok but declining	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and getting worse, Market that is ok but declining and it's Profitable but declining
60	(1,1)	(0,0)	(1,0)	(0,0)	Integrability that can scale	Inadequate investment and getting wor	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and getting worse, Market that is ok but declining and it's Un-Profitable and getting worse
61	(1,1)	(0,0)	(0,0)	(1,1)	Integrability that can scale	Inadequate investment and getting wor	Low market availability and declining	Profitable and improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Low market availability and declining and it's Profitable and improving
62	(1,1)	(0,0)	(0,0)	(0,1)	Integrability that can scale	Inadequate investment and getting wor	Low market availability and declining	Unprofitable but improving	This service system has Integrability that can scale with Inadequate investment and getting worse, Low market availability and declining and it's Unprofitable but improving
63	(1,1)	(0,0)	(0,0)	(1,0)	Integrability that can scale	Inadequate investment and getting wor	Low market availability and declining	Profitable but declining	This service system has Integrability that can scale with Inadequate investment and getting worse, Low market availability and declining and it's Profitable but declining
64	(1,1)	(0,0)	(0,0)	(0,0)	Integrability that can scale	Inadequate investment and getting wor	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability that can scale with Inadequate investment and getting worse, Low market availability and declining and it's Un-Profitable and getting worse
65	(0,1)	(1,1)	(1,1)	(1,1)	Integrability does not meet custom	Adequate investment	Increasing market	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Increasing market and it's Profitable and improving
66	(0,1)	(1,1)	(1,1)	(0,1)	Integrability does not meet custom	Adequate investment	Increasing market	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Increasing market and it's Unprofitable but improving
67	(0,1)	(1,1)	(1,1)	(1,0)	Integrability does not meet custom	Adequate investment	Increasing market	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment, Increasing market and it's Profitable but declining
68	(0,1)	(1,1)	(1,1)	(0,0)	Integrability does not meet custom	Adequate investment	Increasing market	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment, Increasing market and it's Un-Profitable and getting worse
69	(0,1)	(1,1)	(0,1)	(1,1)	Integrability does not meet custom	Adequate investment	Market share is low but improving	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market share is low but improving and it's Profitable and improving
70	(0,1)	(1,1)	(0,1)	(0,1)	Integrability does not meet custom	Adequate investment	Market share is low but improving	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market share is low but improving and it's Unprofitable but improving
71	(0,1)	(1,1)	(0,1)	(1,0)	Integrability does not meet custom	Adequate investment	Market share is low but improving	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market share is low but improving and it's Profitable but declining
72	(0,1)	(1,1)	(0,1)	(0,0)	Integrability does not meet custom	Adequate investment	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market share is low but improving and it's Un-Profitable and getting worse
73	(0,1)	(1,1)	(1,0)	(1,1)	Integrability does not meet custom	Adequate investment	Market that is ok but declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market that is ok but declining and it's Profitable and improving
74	(0,1)	(1,1)	(1,0)	(0,1)	Integrability does not meet custom	Adequate investment	Market that is ok but declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market that is ok but declining and it's Unprofitable but improving
75	(0,1)	(1,1)	(1,0)	(1,0)	Integrability does not meet custom	Adequate investment	Market that is ok but declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market that is ok but declining and it's Profitable but declining
76	(0,1)	(1,1)	(1,0)	(0,0)	Integrability does not meet custom	Adequate investment	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment, Market that is ok but declining and it's Un-Profitable and getting worse
77	(0,1)	(1,1)	(0,0)	(1,1)	Integrability does not meet custom	Adequate investment	Low market availability and declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Low market availability and declining and it's Profitable and improving
78	(0,1)	(1,1)	(0,0)	(0,1)	Integrability does not meet custom	Adequate investment	Low market availability and declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment, Low market availability and declining and it's Unprofitable but improving
79	(0,1)	(1,1)	(0,0)	(1,0)	Integrability does not meet custom	Adequate investment	Low market availability and declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment, Low market availability and declining and it's Profitable but declining
80	(0,1)	(1,1)	(0,0)	(0,0)	Integrability does not meet custom	Adequate investment	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment, Low market availability and declining and it's Un-Profitable and getting worse
81	(0,1)	(0,1)	(1,1)	(1,1)	Integrability does not meet custom	Inadequate investment and but its incre	Increasing market	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Increasing market and it's Profitable and improving
82	(0,1)	(0,1)	(1,1)	(0,1)	Integrability does not meet custom	Inadequate investment and but its incre	Increasing market	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Increasing market and it's Unprofitable but improving
83	(0,1)	(0,1)	(1,1)	(1,0)	Integrability does not meet custom	Inadequate investment and but its incre	Increasing market	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Increasing market and it's Profitable but declining
84	(0,1)	(0,1)	(1,1)	(0,0)	Integrability does not meet custom	Inadequate investment and but its incre	Increasing market	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Increasing market and it's Un-Profitable and getting worse
85	(0,1)	(0,1)	(0,1)	(1,1)	Integrability does not meet custom	Inadequate investment and but its incre	Market share is low but improving	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market share is low but improving and it's Profitable and im
86	(0,1)	(0,1)	(0,1)	(0,1)	Integrability does not meet custom	Inadequate investment and but its incre	Market share is low but improving	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market share is low but improving and it's Unprofitable but i
87	(0,1)	(0,1)	(0,1)	(1,0)	Integrability does not meet custom	Inadequate investment and but its incre	Market share is low but improving	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market share is low but improving and it's Profitable but de
88	(0,1)	(0,1)	(0,1)	(0,0)	Integrability does not meet custom	Inadequate investment and but its incre	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market share is low but improving and it's Un-Profitable and
89	(0,1)	(0,1)	(1,0)	(1,1)	Integrability does not meet custom	Inadequate investment and but its incre	Market that is ok but declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market that is ok but declining and it's Profitable and improv
90	(0,1)	(0,1)	(1,0)	(0,1)	Integrability does not meet custom	Inadequate investment and but its incre	Market that is ok but declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market that is ok but declining and it's Unprofitable but impr
91	(0,1)	(0,1)	(1,0)	(1,0)	Integrability does not meet custom	Inadequate investment and but its incre	Market that is ok but declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market that is ok but declining and it's Profitable but declini
92	(0,1)	(0,1)	(1,0)	(0,0)	Integrability does not meet custom	Inadequate investment and but its incre	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Market that is ok but declining and it's Un-Profitable and get
93	(0,1)	(0,1)	(0,0)	(1,1)	Integrability does not meet custom	Inadequate investment and but its incre	Low market availability and declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Low market availability and declining and it's Profitable and
94	(0,1)	(0,1)	(0,0)	(0,1)	Integrability does not meet custom	Inadequate investment and but its incre	Low market availability and declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Low market availability and declining and it's Unprofitable b
95	(0,1)	(0,1)	(0,0)	(1,0)	Integrability does not meet custom	Inadequate investment and but its incre	Low market availability and declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Low market availability and declining and it's Profitable but
96	(0,1)	(0,1)	(0,0)	(0,0)	Integrability does not meet custom	Inadequate investment and but its incre	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and but its increasing, Low market availability and declining and it's Un-Profitable
97	(0,1)	(1,0)	(1,1)	(1,1)	Integrability does not meet custom	Adequate investment but reducing	Increasing market	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Increasing market and it's Profitable and improving
98	(0,1)	(1,0)	(1,1)	(0,1)	Integrability does not meet custom	Adequate investment but reducing	Increasing market	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Increasing market and it's Unprofitable but improving
99	(0,1)	(1,0)	(1,1)	(1,0)	Integrability does not meet custom	Adequate investment but reducing	Increasing market	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Increasing market and it's Profitable but declining
100	(0,1)	(1,0)	(1,1)	(0,0)	Integrability does not meet custom	Adequate investment but reducing	Increasing market	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Increasing market and it's Un-Profitable and getting worse
101	(0,1)	(1,0)	(0,1)	(1,1)	Integrability does not meet custom	Adequate invetment but reducing	Market share is low but improving	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market share is low but improving and it's Profitable and improving
102	(0,1)	(1,0)	(0,1)	(0,1)	Integrability does not meet custom	Adequate invetment but reducing	Market share is low but improving	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market share is low but improving and it's Unprofitable but improving
103	(0,1)	(1,0)	(0,1)	(1,0)	Integrability does not meet custom	Adequate invetment but reducing	Market share is low but improving	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market share is low but improving and it's Profitable but declining
104	(0,1)	(1,0)	(0,1)	(0,0)	Integrability does not meet custom	Adequate invetment but reducing	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market share is low but improving and it's Un-Profitable and getting wo
105	(0,1)	(1,0)	(1,0)	(1,1)	Integrability does not meet custom	Adequate invetment but reducing	Market that is ok but declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market that is ok but declining and it's Profitable and improving
106	(0,1)	(1,0)	(1,0)	(0,1)	Integrability does not meet custom	Adequate invetment but reducing	Market that is ok but declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market that is ok but declining and it's Unprofitable but improving
107	(0,1)	(1,0)	(1,0)	(1,0)	Integrability does not meet custom	Adequate invetment but reducing	Market that is ok but declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market that is ok but declining and it's Profitable but declining
108	(0,1)	(1,0)	(1,0)	(0,0)	Integrability does not meet custom	Adequate invetment but reducing	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Market that is ok but declining and it's Un-Profitable and getting wors
109	(0,1)	(1,0)	(0,0)	(1,1)	Integrability does not meet custom	Adequate invetment but reducing	Low market availability and declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Low market availability and declining and it's Profitable and improvin
110	(0,1)	(1,0)	(0,0)	(0,1)	Integrability does not meet custom	Adequate invetment but reducing	Low market availability and declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Low market availability and declining and it's Unprofitable but improv
111	(0,1)	(1,0)	(0,0)	(1,0)	Integrability does not meet custom	Adequate invetment but reducing	Low market availability and declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Low market availability and declining and it's Profitable but declining
112	(0,1)	(1,0)	(0,0)	(0,0)	Integrability does not meet custom	Adequate invetment but reducing	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Adequate investment but reducing, Low market availability and declining and it's Un-Profitable and getting
113	(0,1)	(0,0)	(1,1)	(1,1)	Integrability does not meet custom	Inadequate investment and getting wor	Increasing market	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Increasing market and it's Profitable and improving
114	(0,1)	(0,0)	(1,1)	(0,1)	Integrability does not meet custom	Inadequate investment and getting wor	Increasing market	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Increasing market and it's Unprofitable but improving
115	(0,1)	(0,0)	(1,1)	(1,0)	Integrability does not meet custom	Inadequate investment and getting wor	Increasing market	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Increasing market and it's Profitable but declining
116	(0,1)	(0,0)	(1,1)	(0,0)	Integrability does not meet custom	Inadequate investment and getting wor	Increasing market	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Increasing market and it's Un-Profitable and getting worse
117	(0,1)	(0,0)	(0,1)	(1,1)	Integrability does not meet custom	Inadequate investment and getting wor	Market share is low but improving	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market share is low but improving and it's Profitable and impro
118	(0,1)	(0,0)	(0,1)	(0,1)	Integrability does not meet custom	Inadequate investment and getting wor	Market share is low but improving	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market share is low but improving and it's Unprofitable but imp
119	(0,1)	(0,0)	(0,1)	(1,0)	Integrability does not meet custom	Inadequate investment and getting wor	Market share is low but improving	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market share is low but improving and it's Profitable but declin
120	(0,1)	(0,0)	(0,1)	(0,0)	Integrability does not meet custom	Inadequate investment and getting wor	Market share is low but improving	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market share is low but improving and it's Un-Profitable and ge
121	(0,1)	(0,0)	(1,0)	(1,1)	Integrability does not meet custom	Inadequate investment and getting wor	Market that is ok but declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market that is ok but declining and it's Profitable and improving
122	(0,1)	(0,0)	(1,0)	(0,1)	Integrability does not meet custom	Inadequate investment and getting wor	Market that is ok but declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market that is ok but declining and it's Unprofitable but improvi
123	(0,1)	(0,0)	(1,0)	(1,0)	Integrability does not meet custom	Inadequate investment and getting wor	Market that is ok but declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market that is ok but declining and it's Profitable but declining
124	(0,1)	(0,0)	(1,0)	(0,0)	Integrability does not meet custom	Inadequate investment and getting wor	Market that is ok but declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Market that is ok but declining and it's Un-Profitable and gettin
125	(0,1)	(0,0)	(0,0)	(1,1)	Integrability does not meet custom	Inadequate investment and getting wor	Low market availability and declining	Profitable and improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Low market availability and declining and it's Profitable and im
126	(0,1)	(0,0)	(0,0)	(0,1)	Integrability does not meet custom	Inadequate investment and getting wor	Low market availability and declining	Unprofitable but improving	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Low market availability and declining and it's Unprofitable but i
127	(0,1)	(0,0)	(0,0)	(1,0)	Integrability does not meet custom	Inadequate investment and getting wor	Low market availability and declining	Profitable but declining	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Low market availability and declining and it's Profitable but dec
128	(0,1)	(0,0)	(0,0)	(0,0)	Integrability does not meet custom	Inadequate investment and getting wor	Low market availability and declining	Un-Profitable and getting worse	This service system has Integrability does not meet customer standards but improving with Inadequate investment and getting worse, Low market availability and declining and it's Un-Profitable and
129	(1,0)	(1,1)	(1,1)	(1,1)	Integrability is ok but customers ar	Adequate investment	Increasing market	Profitable and improving	This service system has Integrability is ok but customers are complaining with Adequate investment, Increasing market and it's Profitable and improving
130	(1,0)	(1,1)	(1,1)	(0,1)	Integrability is ok but customers ar	Adequate investment	Increasing market	Unprofitable but improving	This service system has Integrability is ok but customers are complaining with Adequate investment, Increasing market and it's Unprofitable but improving
131	(1,0)	(1,1)	(1,1)	(1,0)	Integrability is ok but customers ar	Adequate investment	Increasing market	Profitable but declining	This service system has Integrability is ok but customers are complaining with Adequate investment, Increasing market and it's Profitable but declining
132	(1,0)	(1,1)	(1,1)	(0,0)	Integrability is ok but customers ar	Adequate investment	Increasing market	Un-Profitable and getting worse	This service system has Integrability is ok but customers are complaining with Adequate investment, Increasing market and it's Un-Profitable and getting worse
133	(1,0)	(1,1)	(0,1)	(1,1)	Integrability is ok but customers ar	Adequate investment	Market share is low but improving	Profitable and improving	This service system has Integrability is ok but customers are complaining with Adequate investment, Market share is low but improving and it's Profitable and improving
134	(1,0)	(1,1)	(0,1)	(0,1)	Integrability is ok but customers ar	Adequate investment	Market share is low but improving	Unprofitable but improving	This service system has Integrability is ok but customers are complaining with Adequate investment, Market share is low but improving and it's Unprofitable but improving
135	(1,0)	(1,1)	(0,1)	(1,0)	Integrability is ok but customers ar	Adequate investment	Market share is low but improving	Profitable but declining	This service system has Integrability is ok but customers are complaining with Adequate investment, Market share is low but improving and it's Profitable but declining
136	(1,0)	(1,1)	(0,1)	(0,0)	Integrability is ok

Appendix R – IT Service System VSM

IT Service System Viable System Model



Appendix S – IT Service System Homeostatic Loop Analysis

