Designing Strategic Information Systems in Complexity Science Concepts
Abstract

Aligning strategic information systems (SISs) with business objectives poses a big challenge, alignment is a complex and a dynamic process, especially with shifting business strategies. Advancement in the digital age has altered the dynamism of SISs, deployment of these ubiquitous technologies has increased competitive capabilities in organizations, as well as turned SIS management into chaotic affair. SISs are turbulent, non-linear, open, dancing systems: these features have introduced uncertainty and unpredictability, resulting into problematic alignment of SISs. Complexity science is thought to offer a solution in this alignment chaos; it is concerned with dynamism of the system.

The research in this thesis focused on SISs design, designing SISs in conformity to complexity science concepts. It analyses complexity science use in SISs design. Complexity science constitutes complex adaptive and evolving systems (CAS & CES), both referred to as complex systems hereafter. To achieve SISs alignment with business objectives, organizations would not only need to design alignment applications, but also aligned network structures that enable strategic knowledge sharing, for competitive advantages. The diversity and the non-linear topology of SISs, does not allow organizations to isolate themselves from the outside world anymore; in the digital era competitive advantages arise from shared information. This thesis proposed the use of Knowledge Assets Value Dynamics Map (KAVDM) to determine the priority and order for sharing knowledge assets and for value conversion in organizations, so as to implement the proposed design.

Aligned network topology introduces the network paradigm, which deals with inter-organizational network strategies. The paradigm focuses on organizational systems connectivity for competitive advantages. Complexity science was explored for SISs networked interactions, for inter-organizations alliance benefits; demonstrating the use of dynamic network alignment that adapts and evolves as the organizations knowledge needs rises. The resultant SISs network was redundant, self-regulating, and self-learning. This thesis used simple Generative Network Automata (GNA) to demonstrate that the distributed network topology can adapt and evolve simultaneously as single computational framework, conforming to the complexity concepts.

This thesis employed design science research methodology combined with analytical research. It explored existing knowledge on complexity science, investigated and analyzed it possibilities for improving SISs design. This thesis also suggested how SISs should be designed in conformity to complexity science concepts. The thesis’ contribution was a conceptual model, a suggestion to the information systems research community. A literature review was applied while studying existing knowledge in SISs, open data, network paradigm and complexity science. Most publications came from MIS Quarterly (MISQ), Information Systems Research (ISR), IEEE Xplore, and Journal of Strategic Information Systems (JSIS).

Keywords: Complexity science, complex adaptive systems, complex evolving systems, strategic information systems, information systems alignment, information systems planning, open data, network paradigm
Foreword

My sincere gratitude to the entire information processing department, my fellow students, friends and family who have offered their unwavering support to me during my studies at the University of Oulu.

This thesis is a crowning work of my studies at the University, a few words can never capture the zeal and the effort invested in writing it. My thanks goes to Dr. Tero Vartiainen under whose supervision this thesis was developed, his intellectual support made this thesis a reality. Thanks to Banji Li, a devoted researcher, by whose insight and guidance we were able to navigate through challenging issues of my thesis work. To both Tero and Ben, your devotion to the academic research adds value to a brighter future.

Thanks to University of Oulu for allowing me the opportunity to advance my studies, God bless.

Kagiri Thomas

Oulu, May 22, 2013
Abbreviations

- Information systems (ISs)
- Strategic information systems (SISs)
- Generative Network Automata (GNA)
- Knowledge Assets Value Dynamics Map (KAVDM)
- Information Systems Research (ISR)
- Journal of Strategic Information Systems (JSIS)
- Complex Adaptive Systems (CAS)
- Complex Evolving Systems (CES)
- Information Technology (IT)
- Information Systems (IS)
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1. Introduction

Merali, Papadopoulos, and Nadkarni (2012) proposed a conceptualization of Strategic Information Systems (SISs) as complex adaptive systems (CAS), with the network paradigm, aiding the design for future SIS. Therefore, they called for extension of their work towards the realization of a complex adaptive and evolving (complex systems). The research findings that SISs had adaptive and evolutionary capabilities in their own processes convinced the researchers that SISs could address strategic competitive issues in the digitized business world. In addition, this thesis seeks to strengthen the role of strategic information systems as a knowledge elicitation and management tool. Borgatti and Foster (2003) asserted that knowledge management, a vital component for implementing business strategies in organizations, may have lost meaning due to unsuccessful attempts to use technological solutions in aiding organizations to share and create intelligence. Therefore, this study will attempt to re-assure pundits that initial failures should not be used to write-off technology as an enabler, by demonstrating that knowledge can be created, explored, discovered, managed and shared successfully through SISs. Due to Web 2.0 technologies and social media, knowledge management has received a new dimension, it involves data sharing concepts. As this fact is acknowledged in this thesis, open data concept is proposed as new way for inter-organizational knowledge sharing strategy (Halonen, 2012).

SISs are a hybrid of IT and strategic business opportunities, designed to aid the corporate mission (Hemmatfar, Salehi, and Bayat, 2010). SISs are among the most researched information science topics in recent years (Ahlemann, 2009), and they are viewed mostly in one perspective; that of mechanizing organizational processes for efficiency, control and effectiveness. However, they are not themselves considered tools for increasing corporate competitiveness (Infuente, n.d.). SISs are typically utilized to streamline and quicken the reaction time to environmental changes and aid business in achieving a competitive advantage (Hemmatfar et al., 2010).

1.1 Strategic Information Systems

Strategic Information Systems are defined as systems that help companies change or alter their business strategy and/or structure. SISs give competitive advantages to an organization through the use of information technology (IT) infrastructure, e.g. delivering low priced quality products and or services, faster and more efficiently to the market, for competitive advantages. Strategic information systems can be an application or a computer technology that enables business strategy formulation and implementation, one that poses distinctive capabilities or positioning advantages. SISs consist of innovative applications that modify specific business processes and functionality, like an intelligent booking system that suggests the cheapest flights for various clientele depending on the customer location, flight departure time, and airport landing charges. It can also be an integrated manufacturing computer system that increases the speed of processing and packaging while consuming less energy, and requiring minimal human intervention (Merali et al., 2012). Knowledge management is just one of the business strategies, popularly implemented in many organizations. The use of information technology infrastructure as an enabler to knowledge management
implementation is the main focus in this study. Organizations can become more competitive depending on how they innovate to maximally manage their knowledge inside and outside the organization’s repositories. The use of networked IT infrastructure, strategically designed to enable the firm to achieve the ultimate results of knowledge management for competitive advantages is hereafter referred to as strategic information systems (Merali et al., 2012).

1.2 Complexity science and Strategic Information Systems

Complex systems consist of networked autonomous agents that make choices by considering their environment. They adapt and fit, they evolve by learning and conforming to their surroundings for survival. The system collectively evolves and self organizes in response to environmental factors, which can change rapidly. The concept of complexity science/theory allows information systems experts to understand how SISs considered as “living” systems in organizations, can be designed to adapt, evolve and learn from the rugged and dynamic competitive environment, especially in a mutually benefiting network of organizations. By identifying ecological co-evolution patterns that arise from the complexity science, experts can create applications that imitate the same behaviors. SISs developed along the complexity paradigm can sense, adapt, evolve and learn through the interactions (Li et al., 2010).

SISs have the capacity to evolve (Merali et al., 2012), thus adapting and expanding as the organization information needs change. Organizations are faced by complex competitive challenges owing to uncertainty and unpredictable social, economic and political environments (Merali et al., 2012). To confront these difficulties SISs’ design and implementation have to be modified to conform to a more innovative scientific theoretic frameworks (Merali et al., 2012). These theories have to address complexities of diverse systems, as SISs can be (El Sawy et al., 2010). El Sawy et al., (2010) propose configuration theory as opposed to the more common traditional theories of variance and processes, defining patterns of unfolding interactions at the systems levels that characterize the complexity. Otherwise, the non-linear dynamics emergence and the diversity of information systems results into a chaotic system. Making alignment and planning problematic (Merali et al., 2012), designing SISs to emulate complex evolving/Adapting systems patterns fits the purpose (Oh and Pinsonneault, 2007).

Complexity science can be used to describe how the world operates; it is therefore a multidisciplinary approach that encompasses systems development among others. This study seeks to advocates for complexity science concepts inclusion in SISs design, by considering both information systems assets and business strategies in organizations. Learning is a vital component of complexity science, learning can be facilitated through data sharing (Halonen, 2012). Organizations may from inter-organizational alliances for knowledge sharing or join open data movements. Open data is an emerging trend within the limits of open source movement Manyika, Chui, Brown, Bughin, Roxburgh and Byers, (2011). Computer networks facilitate interactions and knowledge sharing, they are complex systems as well. Co-evolution cannot exist in exclusion, adaptability and evolution cannot exist in a vacuum. Therefore, organizations have to share their knowledge repositories within a defined range, to harness new knowledge from different schools of thoughts. As organizations struggle to stay competitive in the wake of digital competitiveness, there exists a need for robust and effective remedies to the challenges, calling for more intelligent solutions. Organizations need to be more
responsive to environmental changes and fast in adapting to new industrial order. There is need to re-engineer business processes configuration in the face of uncertain competitive challenges, personnel also have to change the way they think so as to accommodate changes faster (Merali et al., 2012).

Why design SIS in complexity?

Complex systems are composed of several independent parts, called agents. Each agent can act in unpredictably, however the actions of all the agents are interconnected to produce the whole system (Eoyang, 2004). So are SISs. They constitute distributed independent systems, which act alone but contribute to the whole system. This thesis advocates for a distributed SISs, a networked system of inter-organizational knowledge sharing repositories, for competitive advantages. The tentative model advocates for development of individual SISs resources in the organization first, before considering joining a knowledge sharing alliance. The inter-organizational alliance’s members would eventually share their knowledge and resources forming a distributed complex structure of SISs assets; a complex network of inter-organizational SISs. The concepts of complexity science aids in understanding, designing and developing self-organizing, adaptive, evolving and learning SISs, for competitive advantages. Current SISs are characterized by chaos and turbulence, most of them are designed for use inside the organization only (Merali et al., 2012). Complexity science concepts give SISs alignment and operational order for free (Eoyang, 2004).

Some SISs assist in organizational planning, auditing, financing and overall decision making, factors that are crucial for organizational competitiveness. Successful implementations of these processes depend on the availability of information. However, these functions cannot be achieved if the stored knowledge cannot be used to add value in the organization. Speed is an essential factor in decision making, and especially in competition, therefore, SISs should offer quick responses to challenges. The difficulties lie in designing information systems (ISs) strategically to ensure that they align with business strategies. The focus is in systems alignment, creation of automated alignment order between ISs and business strategies, this entails designing and developing software and systems for strategic alignment. The goal of this study is to identify complexity science concepts and its principles of interaction patterns, so as to attempt to create a conceptual model for designing SISs. Complex adaptive systems (CAS) are constituents of complex science, and they have been studied in depth in natural sciences field (Eoyang, 2004; Kauffman, 1993). CAS agents are known to be self-organizing, adaptive, learning and evolving. Kauffman, (1993) has published his research on complex systems. He argues that based on the interaction patterns and principles of evolution complex systems concepts can enable SISs experts to design applications and systems that assist organizations in achieving sustainable competitive systems (Merali et al., 2012; Kauffman, 1993; Li, Yang, Sun, Ji, & Feng, 2010). This thesis will analyze complexity science concepts at an abstract level, enough to build a tentative conceptual model, to create an interest in SISs experts, so that they can hopefully carry on with the research in future of complex SISs. This study tries to break the grounds for creation of self-governing strategic information systems.

One of the major reasons why Wall Street banks crumbled in the face of economic crisis was lack of crucial risk analysis information that could have warned the banking
fraternity well in advance (Al-Surqri, Al-Kindi, & Al-Sarmi, 2010). Moreover, there lacked emergency response mechanism to salvage what remained of the industry before the final blow. Wall Street banks boast of the best information systems, however, despite the state of art ISs the banking industry failed to utilize stored knowledge appropriately, which could have saved the industry (Hansell, 2008). Organizations collect a lot of information through time. How they design the knowledge repositories determines how fast they can access the content in the hour of need (Meral et al., 2012). Wall Street banks’ left hands never knew what the right hands were doing. There was lack of proper information delivery within the organizations. There was enough information to warn the bankers of the dangerous banking practices, yet the information never surfaced. It was in chaotic planning, there was no strategic ISs alignment to strategic banking practices. Banks lacked SISs alignment with business targets and objectives. The bankers did not even know how deep they were in the mess, because they thought their ISs were strategically positioned in line with banking processes; they trusted a chaotic system (Al-Surqri, Al-Kindi, & Al-Sarmi, 2010). There was a general perception that in adversity there would be alarms blaring and red-lights flashing. The world’s biggest banks, possessed the most modern ISs, yet they failed to alert them of impending calamity. Everyone was caught unaware. The perception was that they were too big to fail. Bankers continued betting on mortgage securities, against the broke American society, in effect diminishing the value of the world’s trading currency (Hansell, 2008; Al-Surqri, Al-Kindi, & Al-Sarmi, 2010).

Strategic information systems applications and systems development ought to be aligned with business processes and strategies so as to give challenges the priority and attention they deserve. In order for organizations to achieve strategic positioning for competitive advantage through ISs, they have to implement a structured information systems planning strategy that can maintain the organization’s agility and effectiveness in evolving competitive environment (Merali et al., 2012.). Alignment is a complex issue and a dynamic process as well, especially where shifting targets exist, as is the case in business strategies, due to the ever changing business goals and objectives (Oh & Pinsonneault, 2007). Research on non-linearity of complex systems provides a contribution for aligning chaotic systems. It suggests that organizations are dynamic dance-like systems, because they are continuously on the move and unsettled. Eventually, organization’s systems remain in disequilibrium status, characterized by alignment chaos. It should be noted that a slight difference of fit between business strategies and information systems can result into big variations in organizational performance. Merali et al., (2012) fathom a sustainable alignment could be an illusion, given the speed of change in both business and technological world. In addition to the challenges posed by attaining an alignment, competition landscape uncertainties present difficulties in selecting the correct dimensions for SISs alignment. (Tanriverdi et al., 2010) argues that dynamism and uncertainty of disequilibrium in the rugged competitive environment, is reason enough to stop thinking about alignment in-terms of linearity. His advice to ISs experts is to forge ahead and adopt co-evolution strategies instead, so that organizations can retain viability through evolutionary process. Complexity science concepts emerge through selection, the second generation adapts and becomes stronger than the first. Organisms learn, adapt and change through evolutionary process (Kauffman, 1993). Evolutionary facilitates continuous development and formation of new relationships that are aligned with the changing environment for competitive advantages. We can design ISs strategically to align with business strategies along complexity science principles, where an automatic equilibrium can be achieved.
1.3 What is the contribution to the industry?

Knowledge-based enterprises require efficient management of stored knowledge assets, in order to: ensure shift readiness, deliver change in a short period of time so as to sustain survival, counter attack competition and recover (Clark, Cavanaugh, Brown, & Sambamurthy, 1997). Organizations should focus on knowledge management and knowledge based strategies software applications and systems design. Information technology is an enabler. It can aid in knowledge storage, elicitation, exploration and delivery. Information technology enhances efficiency, compared to filing systems. By designing distributed SISs organizations can benefit from shared knowledge and resources. Strategic economic zones for knowledge sharing can be formed for competitive advantages. Organizations can no longer exist in isolation, but rather in collaboration for competitiveness (Meral et al., 2012). It is as important to highlight the importance of efficient knowledge sharing between personnel and devices inside the organization and utilization of SISs to develop expertise in the organization, as it is to acquire state of art information systems resources (Holsapple et al., 2000). ISs have a major role in business operations, additionally, they aid in reaching for quick decisions (Rockart, 1979). Until recently ISs had been perceived as a back office operation, however, with recent technological advancement, ISs have achieved new status as strategic weapons of competition. This calls for smart strategies and innovative ideas, for strategic decisions making (Meral et al., 2012).

System integration is crucial for strategic alignment of information systems and business strategies, for SISs derived competitive advantages. The scope of integration in IT has no horizon, because information technology is considered as a trigger for dynamism due to its pervasiveness and fast mode of change. The focus remains on how to strategize for quick response and fast recovery in line with business processes so as to remain competitive through the changes (El Sawy, Malhotra, & Pavlou, 2010). To answer this question we have to consider the issue of synergetic relationship between IT and organization’s resources in enabling the change shift, we also have to factor in inter-organizational collaboration for knowledge sharing. These crucial components have to co-exist, co-adapt and co-evolve in unison to enable strategic re-invention, renewal and re-positioning every time the dynamics of competition changes. It is important for the organizations to maintain and improve their competitiveness in the wake of every change (Merali et al., 2012).

Knowledge management and maintenance of integrated strategic information systems are centered on exploration and exploitation of organizations’ existing competencies, technologies and information resources. Strategic information systems in this particular context may mean an algorithmic application, developed as an innovative search engine for the internally stored knowledge assets and shared repositories. Such mechanisms are vital for exploration of knowledge and creation of intelligence for organizational, survival, counter attack and recovery processes (El Sawy, Malhotra, & Pavlou, 2010).

1.4 Prior research

Strategic information systems research and practice was first established as an important feature in business strategy framework in 1980s (Chen, Mocker, Preston & Teubner, 2010; Luftman & Kempaiah, 2008). Over the years the issue of alignment has
dominated the discussions at managerial meetings in organizations and has kept many researchers busy. However, scholars have focused more on organizational factors affecting alignment, rather than alignment with business strategies planning (Roepke, Agarwal, & Ferratt, 2000; Stephens, Ledbetter, William, Mitra, & Ford, 1992; Watson, 1990). Some academic literature has focused on IT leadership and importance of business champions in establishing ISs as a strategic tool in business (Beath, 1992). Eventually, scientists created a shift which emerged supporting IS-business inter-relationship. This change encouraged senior executives’ involvement in ISs planning, partly due to the shared objectives between ISs developers and businessmen (Emery, 1990). The IS-business relationship gave birth to a broad external focus in establishing IT capabilities and possibilities in business strategies. Despite the steady growth of research and innovation in the information systems field, only a handful of researchers have involved themselves with ISs alignment with business strategy (Bergeron, Buteau, & Raymond, 1991; Earl, 1993; Watson, 1990). In the recent past few researchers have tackled SISs research topics, and from the year 2008 there have been several notable research papers on SISs and complexity science or complex systems. Authors of those papers seem to share the same objective, that of innovative ways to improve ISs in aiding business strategy (Merali et al., 2012).

The context of SIS research has been changing over the years to deliver innovative design models, taking advantage of the ISs capabilities. However, the practice domain has been static despite being stable over the last decade (Merali et al., 2012). Common among the scholars, is the view that researchers have to adopt new perspectives (new ways of thinking) while researching for SISs improvements. A few researchers have urged others to look into complex science for deeper insight on ways of developing SIS (Nevo and Wade, 2010).

1.5 Research question

- How can strategic information systems be designed in complexity science concepts to harness competitive intelligence?

Complexity science is a scientific study of complex systems consisting of small parts called agents, which are independent (autonomous), which interact with each other to form a global behavior that cannot be easily explained in terms of relationships between the individual elements. Complex systems examples include information technology (IT) networks, brain neurons, ecology, etc. Complexity science concepts characterizes the rules of nature, no matter how much it rains, all the water finds itself back to the rivers, lakes, streams and eventually to the ocean, the water system is self-governing and the water cycle never stops. In the ecology, termites despite their tiny and fragile body structure, coordinate themselves to build the most complicated housing structure, every one of them executes its responsibility to the letter without failure, queen guards, food hunters, soldiers etc. Termite shelters are considered as the most complex architecture in the world, with several escape routes, well moistened and well ventilated. The rule of complexity science is self-governing, adaptive, learning and evolving. Take the human brain for example. The cow eats grass, the man eats meat, the man dies, and the grass is nourished by manure, never does the cycle end (Railsback, 2000).

1.6 Research methods

This study employed design science research methodology combined with conceptual-
analytical research. This thesis explored and evaluated the potential for complexity science concepts to improve SISs efficiency and effectiveness in the wake of organizational competitive challenges. The focus was on how SISs alignment with business strategy could be designed in conformity to complexity science concepts and principles. Literature review was applied to existing knowledge in SISs, open data, network paradigm and complexity science. Most publications came from MIS Quarterly (MISQ), Information Systems Research (ISR), IEEE Xplore and Journal of Strategic Information Systems (JSIS), retrieved from the university library databases.

1.7 Study’s main contribution

This study aims to contribute in SIS research, by proposing a conceptual model for designing SISs in conformity to complexity science concepts. The study aims to introduce a new thinking, a conceptual model for strategic ISs alignment with business strategies, through knowledge management. The study will tackle issues of dynamic complexities in SISs and the network paradigm, in technical and social contexts. It takes into account the digitally inter-connected socio-economies (organizations). Inter-organizational alliances interactions are enabled through information technology (IT) capabilities (Chan & Huff, 1997). The alliances are motivated by the industrial growth and development, and forces of demand and supply (March, 1991). Considering the turbulent, uncertain and dynamic industrial competition, the study proposes complexity science as the base for a conceptual framework for SISs design. SISs are themselves complex adaptive systems which can be designed to exploit their diversity and adaptive capacity in order to evolve and yield knowledge for human consumption, increasing readiness, efficiency and effectiveness against uncertainties (Abebe & Angriawan, 2013).

1.8 Structure

This thesis consists of an introduction, frameworks presenting relevant theories, research strategy used, thesis building consisting of frameworks 1, 2 and 3, findings of the study, discussion of the topic and a conclusion.

The introduction presents the background of the topic, the purpose of the study, and the motivation of the research. It explains the driving factors arriving to this topic, prior research and a brief introduction to strategic information systems. The history of SISs is evaluated and contrasted against practical achievements so far. The research question is posed and explained, while the main contribution of this thesis is explained. Chapter two presents research strategies, from information mining, sorting to paper coding. Design science research methodology is discussed as pertaining to SIS design, and its relationship with conceptual-analytical research in this study, thereafter, future research area is proposed and innovations are discussed in line with the topic. The third chapter reviews the relevant literature, presents and discusses the three main theoretical frameworks: (1) complexity science, (2) network paradigm and (3) open data. In chapter four, a case study is presented depicting distributed SISs for knowledge elicitation, business processes and process learning mechanisms. In chapter 5, the results are presented, a tentative conceptual model. In chapter 6, findings of the study are presented, followed by a discussion of this study in chapter 7 and finally a conclusion remark.
2. Research Strategy (Research problem and methods)

The history of strategic information systems dates back to the last century, however as this thesis has asserted, the SISs domain still lacks sustainable alignment between business strategies and ISs for competitive purposes. Designing SISs within the conformity of complexity science concepts is therefore an attempt to improve the effectiveness of SISs in-line with rapid changing technology and emerging organizational competition challenges, this research seeks to improve SISs design. Järvinen (2004), describes this kind of a study as design science research, he includes: *Change, maintain, extend, correct, adjust, introduce, improve and enhance* as some verbs, if found within the research hypothesis, that would probably lead to a design science research. In addition this study employs conceptual-analytical research to determine: what is realisable in designing SISs by following principles of complexity science? And what is achievable through these concepts? It is not the intent of the author to persuade the readers that the resultant conceptual model is correct or wrong. The intent is to introduce the idea and the model which could result in a better product. Conceptual-analytical research starts with a question, where the author holds no stance, it is a theory and a system based research (Järvinen, 2004)

2.1 Design Science Research Methodology

In this section the research problem is further analysed, from the design science and conceptual-analytical research methodologies’ perspective in an attempt to validate the study. A research method is a systematic scientific investigation of a selected topic, a careful search of new knowledge, a voyage of discovery to the unknown. Research is also a manipulation of concepts, ideas and symbols to extend or verify knowledge in construction of new theory or art (Geerts, 2011). The purpose of research is to discover answers to worthy questions through scientific procedures (Järvinen, 2004). Progress is made from imagination and inquiry, the extent to which an imagining can be transformed into a reality is limited by the discoverable knowledge and presentation of the same. Increased research makes invention progress possible, and a simple idea can be transformed into a new scientific front, given a scientific reasoning and adequate research (Geerts, 2011).

The design science research paradigm is relevant to the ISs field because it supports creation of innovative artefacts. Information systems researchers developed interest in design science (DS) as early as the 1990s. The initial idea of design science developers was to integrate systems development into research process, their methods included: theory building, experimentation, systems development and observations. They felt that these methods were essential for a complete research product. The idea was to merge research and inventive systems, in the process of design and implementation of better theories (Peffers, 2006). Peffers et al., (2006) universally accepted DS conceptual process and mental model for research presentation and evaluation has been used in this study. Järvinen (2004) has written extensively on the six steps of the DS research process and its mental model.
It is upon ISs researchers to further knowledge towards application of information technology in organizations. Strategic information systems deviate from the traditional ISs purposes, which are limited to aiding efficiency and effectiveness, to assisting organizations in achieving a competitive edge. Knowledge communication is vital for competition, as organizations absorb new technology the bar for competence rises, calling for more innovative measures. Design science has its roots in engineering and artificial sciences, it is a problem solving paradigm that seeks to create innovation. DS addresses ISs weak problems that are characterized by: unstable requirements often related to ill-defined environment, rapid changes, dependency on creativity, complex interactions and input dependency (Hevner, & Chatterjee, 2010).

This section uses DS in an attempt to answer the following questions: Can SISs be designed using complexity science concepts to harness competitive intelligence? This question seeks to know whether it possible to design artifacts that poses complexity science principles of: emergence behavior, self-regulating and self-controlling. The final product of this study will be a tentative conceptual model, a model for strategic information systems design. Because our research questions contain the verb design/build and are posed as theoretical questions, our study belongs to design-science and conceptual-analytical research. The objective of the design is to develop sustainable strategic information systems; the study seeks a SISs improvement model.

Design science addresses essential unsolved problems through innovation, it clearly identifies contribution to the literature and it communicates the results to the stakeholders. Innovation is characterized by experimental artefacts, most often artefacts that pose questions. While innovating, existing literature is used extensively in an attempt to create a convincing artefact. However, innovations are characterized by embodying elusive or non-existent knowledge, therefore, creativity is vital, where trial and error is rife. Most industrial executives oppose projects that are based on new ideas; especially IT projects, because the rate of failure has been higher than that of success. However, risk-taking is part of business (Hevner, & Chatterjee, 2010).

Table 1. Design science research guidelines in this study

<table>
<thead>
<tr>
<th>Problem identification &amp; motivation</th>
<th>Objective of the solution</th>
<th>Design &amp; Development</th>
<th>Demonstration</th>
<th>Evaluation</th>
<th>Communication</th>
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<tr>
<td>Strategic information systems lack correct alignment for quick reaction to competition threats</td>
<td>Quick knowledge delivery to the necessary quotas, designing thinking SIS.</td>
<td>Use literature review to provide a conceptual model</td>
<td>Develop a mental model or for SIS design</td>
<td>Use study cases: study artefact in knowledge elicitation mechanism (SIS)</td>
<td>Thesis and or publication. (The research outcome must be communicated to the wider IS practitioners and interested parties through a thesis)</td>
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2.2 What is the problem? (Problem identification)

When organizations are faced with stiff challenges from their competitors, market trends or client demands, there is always the need to respond fast, either by introducing new combative measures or deploying innovative strategies. The time between responses can mean success or failure. Efficiency is determined by how the knowledge is delivered to the right persons or systems. Earlier this study explained lack of ISs
strategic alignment with business strategy, to deploy innovative combative strategies an organization needs all necessary information, at the right time and to the right persons/systems, without which failure is imminent. There is need to design strategic information systems that are aligned with business strategies, so that knowledge elicitation is parallel to current business challenges. To achieve such a system, this study has proposed imitating the behaviour of complex adaptive systems in designing self-regulating, self-controlling and system thinking strategic information systems. The greatest challenge in knowledge delivery includes how to deliver the right information at the right time to the right quotas (people and devices) (Montano-Rubenstein, Liebowitz, Buchwalter, McCaw, Newman, & Rebeck, 2001).

2.3 How should the problem be solved (Defining the objective)

In simple terms the strategic information system should explore, exploit and present knowledge automatically in-line with the current challenge. The SISs can be a software application that has capabilities to deploy a detailed search mechanism across all repositories, within the defined organizational boundaries. The application should be able to study information processing trends from all the agents, by comparing the processing patterns to existing historical patterns and detect dangerous trends, and by generating warning signals to the right persons or generate triggers to specific systems, so that they can deploy automated combative measures. The objective is to design a thinking system. The SISs application should allow multiple activities to take place at the same time, leading to systems learning and evolution (Rubenstein-Montano et al., 2001). Had the Wall Street bankers deployed a thinking strategic information system, the system would have been able to study the computational processes from all departments, compare them with existing patterns and generate automatic reports, which would have served as warning signals, or would have automatically generated solutions/proposals to the necessary people. It is possible to design and develop SISs software that can pick predetermined words from departmental workstations and deduce communications trends, for improved control mechanism.

Objective of the solution

The distributed SISs should deliver aligned knowledge to the necessary people and devices at the right time, in a designed environment. The presentation of the discovered knowledge is made possible by an elicitation mechanism (Nakakoji & Fischer, 1995). This study proposes that SISs should mimic a complex thinking mechanism, like a human brain which is a complex system, so that SISs can deliver knowledge efficiently and effectively. This study will use DS in its quest to propose a SISs design (a distributed knowledge elicitation mechanism that is modelled on complexity science concepts). This thesis analyzes existing literature through theoretical frameworks in an attempt to answer whether it is possible to achieve the desired improvement; therefore this thesis includes conceptual-analytical research, for it builds model on theories. Research is like art, creativity is an essential element; theoretical analysis requires a well-articulated design and presentation, so as to capture the interest of the audience (Järvinen, 2004). Nakakoji and Fischer (1995) observed that organizations are not motivated to articulate knowledge and store it, if they do not perceive immediate benefit for doing so. Therefore, organizations may be interested to capture more information, if they were convinced they would be able to benefit immediately (Hevner, & Chatterjee, 2010).
2.4 Create an artefact that solves the problem

Design science relies on systematic literature review and creativity for innovations (Peffers et al., 2006). The first phase of this research included; gathering, assessing and evaluating all relevant literature. The search terms included: complexity science (complex adaptive systems, complex evolving systems), strategic information systems (information systems alignment, information systems planning), open data, and network paradigm. The results yielded about two hundred research articles, picked in strict order of relevance to thesis’s topics. Relevancy was determined by the contents of the abstract, findings and conclusion. The search sought current publications from top rated databases; the articles included conference proceedings, journals, eBooks, text books and technical reports. The selected materials were saved in four different soft folders, in line with the subject matter; SISs, open data, ISs alignment, complexity science and network paradigm. Each subject was labeled with different colors, meaning all four folders contained papers with relatively same subject matter. In every folder the papers were ranked in the order of relevancy to this study, number one indicating highest priority. The order of relevance was arrived after reading the abstract of the research paper. Later-on, the relevance was evaluated again after reading the introduction, findings and the conclusion of the paper. Number 1a indicated the highest order of relevancy while 1b was second in that order, if the subject content was perceived to be the same. The table below lists ten of the highly prioritized papers in this study.
<table>
<thead>
<tr>
<th>Title of the paper</th>
<th>Year of publication</th>
<th>Authors</th>
<th>Subject Matter (Folders)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information systems strategy: Past, present, future?</td>
<td>2012</td>
<td>Merali, Y., Papadopoulos, T., &amp; Nadkarni, T.</td>
<td>Strategic information systems (SIS) &amp; Complex systems</td>
</tr>
<tr>
<td>Information systems strategy: Reconceptualization, measurement, and implications</td>
<td>2010</td>
<td>Chen, D. Q., Mocker, M., &amp; Preston, D. S.</td>
<td>SIS</td>
</tr>
<tr>
<td>Strategic information systems-enabled organizational transformation: A trans-disciplinary review and new directions</td>
<td>2012</td>
<td>Benson, P., &amp; Rowe, F.</td>
<td>SIS</td>
</tr>
<tr>
<td>Complex systems: Network thinking</td>
<td>2006</td>
<td>Mitchell, M.</td>
<td>Complex systems</td>
</tr>
<tr>
<td>Modelling complex systems with adaptive networks</td>
<td>2012</td>
<td>Sayama, H., Pestov, I., Schmidt, J., Bush, B. J., &amp; Wong, C.</td>
<td>Complex systems &amp; Network paradigm</td>
</tr>
<tr>
<td>Emergence in stigmergic and complex adaptive systems: A formal discrete event systems perspective</td>
<td>2013</td>
<td>Mittal, S.</td>
<td>Complex systems</td>
</tr>
<tr>
<td>Adaptive process for knowledge creation in complex systems: The case of a global IT consulting firm</td>
<td>2006</td>
<td>Xing, B., &amp; Sherif, K.</td>
<td>Knowledge sharing (Knowledge management) &amp; Complex systems</td>
</tr>
<tr>
<td>An intelligent agent-based architecture for strategic information systems applications</td>
<td>2006</td>
<td>Soroor, J., Shirazi, M. A.</td>
<td>SIS &amp; Network paradigm</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>Järvinen, P.</td>
<td></td>
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</table>
Table 2 presents ten of the references that contained most relevant information for this thesis. These reference materials can be found through the university databases listed above.

Information systems can be used for modelling unique business competition strategy, in the organization. Complex systems create survival patterns from environmental interactions that organizations can emulate by crafting sustainable competitive strategies from their surroundings as well, by forming inter-organizational alliances. Through the alliances common repositories can be established for mutual knowledge exploration benefits for competitive reasons. Software applications can be designed for exploring, exploiting and aligning knowledge to strategic business processes. Automated ISs-business strategy alignment can be used to support a sustainable competitive strategy (Dong, Liu, & Yin, 2008). Most organizations have depended on off-the-shelf applications and information systems models to execute their competitive agenda (Chan & Huff, 1997). However, these applications and models are easily modifiable and can be purchased and implemented by any organization, therefore they offer no unique factor, neither do they fully satisfy organizational strategy. Chan and Huff (1997) suggest that organizations should develop tailor made strategic information systems that fit perfectly to their business strategy. Over the years the pace of technology change has increased (El Sawy et al, 2010), concepts have been created and other academic disciplines have merged to share knowledge diversity. From the diversity new models, practices and values have been generated that can be utilized in information systems strategy design (Galliers, 2003, 2006). The table below summarizes SISs trajectory research by Merali at al., (2012) showing a meta-level SISs evolutionary stability over a period of thirty years.
Table 3. SISs field evolutionary trend 1980-2011 (Merali et al., 2012)

<table>
<thead>
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<tbody>
<tr>
<td>Dominant Alignment</td>
<td>Aligning SISs with Business Strategy</td>
<td>Developing SISs for Integration of ISs with Business</td>
<td>Developing SISs for Networks and Resource-based competition (valuing relational, human and knowledge resources)</td>
<td>Developing SISs for complex, dynamic, distributed contexts</td>
</tr>
<tr>
<td>Challenge</td>
<td></td>
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<td>Integration Focus</td>
<td>Systems</td>
<td>Process</td>
<td>Resource</td>
<td>“Global” socio-economic system architectures</td>
</tr>
<tr>
<td>Emergent/adopted IT</td>
<td>Applications Portfolios</td>
<td>Integrated Systems</td>
<td>Enterprise Architectures; Service-Oriented Architectures and Web-based services; Business Intelligence and Knowledge Management Environments</td>
<td>Multi-scale Ecologies; Cloud Computing Web 2.0 and Social Media</td>
</tr>
<tr>
<td>trends</td>
<td></td>
<td>ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) Systems</td>
<td></td>
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</tr>
<tr>
<td>Scope of Strategic</td>
<td>Internal</td>
<td>Industry-linked</td>
<td>Cross-Industry Value webs and Networks</td>
<td>Wider Global-Local Socio-Economic context</td>
</tr>
<tr>
<td>Contextualisation</td>
<td></td>
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<tr>
<td>Scope for Business</td>
<td>Value Chain</td>
<td>Extended Enterprise</td>
<td>Value webs; Global reach</td>
<td>Distributed, Socially Relevant</td>
</tr>
<tr>
<td>Model Innovations</td>
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Table 3, presents Merali et al., (2012) trajectory research on SISs, demonstrating that there exists an opportunity for integrated design concepts from social sciences (such as economics, sociology and strategic management) and also that SISs have a capacity to evolve into better systems. While analysing Merali et al., (2012) literature on complex systems and SISs, a conceptual model for designing distributed strategic information systems started forming. Merali et al., (2012) observed that SISs had the ability to learn, adapt and evolve. Their research showed that while SISs themes remained stable over the years, it incorporated diversity from other disciplines, enabled by changes in technology, applications and conceptual frameworks. However, the evolution has been slow, consistent and smooth to accommodate the technological impact, despite the potentially disruptive technologies introduced in every decade. The adaptive and evolutionary abilities of SISs have extended its integration scope, participation and resource base (Merali et al., 2012). Organizations are no longer just focused in internal alignment of business and ISs but also to resource based strategic global mergers, a process enabled by the computer networks. Organizations are not only engaging internal
players but society as well. According to Merali et al., (2012) nowadays organizations do not just rely on internal information technology resources but to social media and web 2.0 capabilities, to utilize relational and intellectual capital across the organizational boundaries. Their research inspired this thesis to develop a tentative conceptual model for designing distributed SISs.

SISs are dynamic and adaptive (Merali et al., 2012), to define the position of SISs research on socio-economic this thesis studied Nelson’s (2003) theory of technological evolution in which he observed that physical and social technology play a major role in economic growth. “Physical” technology referred to anything information and communication technologies (ICT) while “social” referred to organizations (people and work). Nelson (2003) argued that physical and socio technologies must co-evolve for both society and economy to benefit. SIS is the discipline that is responsible for the physical-social technologies co-evolution (Merali et al., 2012). SISs are multi-level, multi-scale and multi-dimensional and they are focused on creating, acquiring and leveraging IT for competitive positioning (Merali et al., 2012). Nevo and Wade (2010) argue that IT cannot provide a sustainable competitive advantage without knowledge management and organizational resource capabilities. This argument encompasses from local implementation of systems in mother organizations to large scale implementation of global systems, in multi-organizational alliances (Nelson, 2003). This conceptualization has been addressed in this thesis’s artefact, the conceptual model for distributed SISs design.

Information technology (IT) plays a major role in strategic management; IT is viewed as enabler and driver of the network paradigm (network society and economy), (Shapiro & Varian 1999; Axelrod & Cohen, 1999; Evans & Wurster, 2000). ISs sector has experienced increased power and impact on its abilities to connect people, applications and devices. Computer networks enable distributed storage and processing of data, and increased speed of communication and transmission (Shapiro & Varian, 1999). Exploitation of the network capabilities gives rise to networked processing, the network structure becomes a complex computing unit. The network unit enables expertise and knowledge sharing across organizational boundaries. The network is characterized by integrated components (agents) across diverse platforms and business systems. A complex dynamically changing network structure is formed, where agents join and leave freely. Increased connectivity and access to massive volumes of data increases information variety, which constitutes great information complexity (Chaitin, 1990). This creates demand for powerful algorithms and computational capabilities (Merali et al., 2012). Emerging IT capabilities and possibilities in both business and society have given a different definition to complexity, Nevo and Wade (2010) argue that the new systems complexity requires a holistic view, while El Sawy et al., (2010) and Merali et al., (2012) conquer with Nevo and Wade, they recommend use of concepts from complexity science and thinking systems. The position is motivated by the fact that organizations can no longer operate in isolation, rather as networks, so as to compete effectively with the forces of the environment (which contains other inter-linked organizations and resources), (Merali et al., 2012).

The tentative conceptual model for SISs design advocates for strategic organizational mergers, creating shared data repositories for competitive advantage (economic zones for knowledge sharing). The relationship should yield a powerful network of repositories, the agents in this thesis. The resultant network is a powerful system thinking architecture, developed with semantics, algorithms and computational power. On the other hand, each organization should strive to implement an equally powerful internal knowledge management system, internal SISs. The SISs implemented inside the
organization and the networked infrastructure linking the organizations are referred as a single SISs unit, in this thesis. Both systems function independently, but join efforts to emerge as a single unit, that is the concept in complexity science. Components in complex systems function independently, only to merge and emerge as a single powerful unit (Eoyang, 2004). The artefact has to encompass the surrounding environment, it has to factor the input from other organizations in the competition landscape. At the same time the artefact has to be evolving, so as it can facilitate evolutionary growth of knowledge through automatic seeding and reseeding, thus synchronization of internal knowledge and discovered knowledge (from other organizations). The SISs are the brains behind the envisioned sustainable competitiveness, SISs should be automated thinking systems designed with complexity science concepts. This thesis analyzes how the artefact works, thinking systems are connected systems, and they possess effective connectivity, achieved through nervous systems-like connection. The brain’s connectivity facilitates information sharing and processing balance creation and dynamic processing of body functions (Sporns & Bullmore, 2009). The brain and computer networks are characterized by non-linear connectivity, non-linearity achieves equilibrium through dynamic oscillation, the system has to maintain balance as agents join and leave the network (Bucker, Andrew-Hanna, & Schacter, 2008). Dynamism is required so as to facilitate the entire SISs alignment mechanism with self-organization capabilities (Merali et al., 2012). The SISs includes software applications and the entire networked infrastructure. This thesis will demonstrate the artefact, tentative conceptual model for SISs design, it is arrived at after conceptually analyzing the literature review and building-on theories through design science guidelines. The review consisted of key scientific concepts from complexity science.

2.5 Demonstrate the use of the artefact

Design science research guidelines includes demonstration of the artefact, in this case the tentative conceptual model for designing distributed SISs. The artefact calls for development of a process validating mechanism in SISs, so as to implement a processes policing feature. To do so the model proposes algorithm modification to imitate complex systems learning patterns. Complex adaptive systems derive from three physical states, static, dynamic and dynamical systems. The artefact is a dynamical system, it allows changes in response non-linearity (Eoyang 2004). Biological complex systems (organisms) produce patterns every time they interact with each other, these patterns are stored and are used for environmental adaptation and evolution processes. Whenever the organisms encounter a situation they refer back to the stored patterns to validate the relationship (Kauffman, 1993). These kind of patterns can be produced for SISs by designing software applications that validate all the computational processes in the organization’s information systems (user computers, servers, routers, repositories, etc.).

The artefact advocates for distributed SISs, so as to incorporate the surrounding environment into the organization’s processes. The competition landscape contains other organizations, which hold vital information, key to the processes development of other organizations. Inter-organizational alliances are seen as vital for competitive knowledge sharing. These alliances are facilitated by the network paradigm, ISs and inter-organizational connectivity (March, 1991). The network topology is characterized by non-linearity, because of its size and uncontrollable nature. Agents join and leave the network at will, in such a large complex strategic information system equilibrium has to be achieved, so as the entire system can achieve alignment stability (Merali et al., 2012). Ambidexterity in this system entails simultaneous processes of exploration and
exploitation, of knowledge from the outside the mother organization (March, 1991). The distributed SISs model is thought to overcome the challenges of destabilizing effects during the processing of emergent knowledge in complex contexts as observed by Markus et al. (2002). They were concerned with the challenges of designing a system distributed across diverse platforms, involving people, other organizations, markets and evolving dynamics. This tentative SISs design comes in the era of open innovation, at times when Web 2.0, crowd sourcing and cloud computing capabilities are available. Through these technologies organizations can exploit user generated content, therefore transforming their process requirement methods and acquiring efficient means of influencing user behaviors and in dynamical contexts too (Merali et al., 2012). The equilibrium alignment is achieved through the dynamism of the network (Merali et al., 2012), the concepts of complexity science dictate that the nature ultimately acquires it balance (Eoyang, 2004). Knowledge exploration, exploitation and elicitation follows the concepts of complexity science, for the knowledge sharing cycle is non-linear, fluid like, an oscillating net like ring of agents. Nodes of networks (agents) interact via internet enabled networks, in the process of knowledge creation, where thinking systems of repositories are established for organizational knowledge sharing. Such systems are possible, borrowing from the discovered robust synchronization between coupled chaotic systems, which has led to realization of non-linear synchronization that plays an important role in the neural systems (Sporns & Bullmore, 2009). The envisioned SISs thinking systems works almost like the neural system’s processing mechanism. In order to demonstrate the artefact, the study will analyse the nervous system at a very abstract level. Brain mechanism is a perfect example of a thinking complex adaptive system, whose operations are similar to those of the envisioned SISs in this thesis.

![Figure 1](image)

**Figure 1.** A model of distributed SISs, non-linear network (Newcastle University, 2013)

Figure 1 depicts a complex system of communicating agents, or a network of neurons in the brain, nodes acting like agents. The diagram represents a network of agents in the
envisioned strategic information system model. Agents are non-linearly distributed components, in a networked environment. The agent is independent and it is capable of autonomous action, and it resides in the mother organization. An agent is able to communicate with the other agents inside and outside of the organization, react to changes, and initiate a process. An agent can be a computer system, a person, a software or hardware. However, at the end of the individual processes, agents will join efforts to produce a unit system-wide pattern, conforming to principles of complexity science (Tesfatsion, 2003).

The goal of this section is to demonstrate how network patterns organize and manage information sharing in a self-organized environment governed by the laws of complexity science. An environment dictated by natural laws of evolution, order is characterized by chaos (Eoyang, 2004). The brain is a self-organizing, active and dynamic complex system (Tesfatsion, 2003). Neurons networked by electric strands of proteins cooperate with other parts of the brain system, generating patterns which are stored in the memory. The patterns aid humans in processing information around them, enabling them to execute tasks. SISs execute tasks related to organizational competence, they answer to orders generated by agents, mimicking the operations of the brain. This thesis argues that it is possible to emulate the brain processes of pattern formation, while developing strategic information systems. The brain retrieves the stored patterns automatically whenever the need to validate a processes arises (Tesfatsion, 2003), in developing a similar operation for SISs an application of algorithms can be implemented. Whenever a computer is switched-on, a process listening mechanism is deployed (eavesdropping like software application), whenever an order is sent, it is validated against the stored patterns. If a new is encountered, the pattern is stored as a new validating tool. If the process pattern exists and is pre-defined as a bad professional practice, the SISs issues a warning to the order sender and a report is generated and send to pre-programed addresses for inspection. The same kind of programming algorithms should be used to develop software applications for knowledge exploration and exploitation.

The organizational ISs should be designed to align automatically to changing business strategy, so that there is less or no human intervention. Software applications can be design to aid learning of new knowledge from other organizations. When the system acquires such useful knowledge from outside the organization, it should then alert pre-specified personnel and devices so as to re-allocate resources towards the necessary processes for strengthening the organizations competitive advantages. All these processes should produce patterns, necessary for organizational adaptation and evolutionary knowledge management.

A pattern is a resultant design, a combination of qualities, configurations, behaviours and actions. This thesis focuses on the patterns to understand the interrelationships among multiple parts of the complex system, because individual components give limited knowledge or distract the view from the significant patterns emerging from the whole system (Eoyang, 2004). The brain is a pattern forming self-organized system. Just like the intended SISs, it is governed by non-linearity and dynamism. These are broad terms to throw around, however, in this thesis the premises of use have been defined in the earlier chapters. The brain controls and interprets behaviours (Sporns & Bullmore, 2009). These are the desired properties of a thinking system, a SISs designed in complexity science concepts should be able to learn from its environment, detect and remember actions. The stored patterns have a unique feature that cannot be replicated, the pattern contains all the information collected from the agent’s processes (Eoyang, 2004). The production and the storage of the patterns is controlled by the SISs
interactions, the patterns can be formed from a defined area of operation, which extends beyond the organization’s boundaries, (Sporns & Bullmore, 2009; Bucker et al., 2008).

How is self-organization realised in the brain? What are the laws governing such in complex systems? The answers to these questions hold a vital clue in replicating the same behaviour in a software. A brain is governed by the laws of complexity science (Sporns & Bullmore, 2009), in that a small change can initiate very different outcomes, a small change in an environment governed by rules of complexity science, can cause major effects (Eoyang, 2004). This study will not venture into the processes of how brain coordinates processes and how it brings consciousness, or how thoughts are produced without input, because that domain is not important in driving the point home and arguably there may be no knowledge of that. Complex systems such as the brain have a lot of inter-dependent processes, and parts (Sporns & Bullmore, 2009). The connection is facilitated by a network of neurons, which supports the information processing (Bucker et al., 2008). So the software application should inter-connect several processes and parts through the network paradigm, creating a unit SISs.

Just like any network of systems, nervous system is made up of agents that interconnect forming a complex network. The function of the nervous system is to facilitate information transfer, among other functions. The complexity of the nervous system can be compared to that of network topology. The complexity of human brain is demonstrated by the millions of nodes (agents) interconnected by an elaborate network of electric straps, likening the whole network structure to a distributed SISs (Sporns & Bullmore, 2009). Brain connectivity is multi-layered, is made up of individual parts, indicating its complexity. The layers include individual synaptic connections linking single neurons at the tiniest of the scales, neural population at the medium scale and at the brain level (Bucker et al., 2008). A multi-layered systems is just like the organizational network infrastructure, which comprises of several parts, components and processes, inter-connected by the internet. The topology is important in network paradigm description and connectivity propagation. Effective connectivity may be evaluated by the efficiency of the processes and the extent of systems redundancy. The success of agents’ connectivity can be determined by the speed and quality of knowledge delivery, which is determined by the strategic alignment of the business strategy to information systems (Borgatti, & Foster, 2003).

Taking the brain as an example of a complex system. Agents in the artefact represent the neurons, the agents’ communication is facilitated by the network connectivity (Tesfatsion, 2003) while the neurons are connected by electric strands (Sporns & Bullmore, 2009). The SISs software application listens to the communication processes via messages, tracking pre-defined words in the local network, which form a pattern hence stored in the memory. The patterns are used for validating gathered knowledge, systems requests and network joining agents. The software application for knowledge management is also supposed to evaluate which patterns are relevant, which patterns should be stored for future use and which patterns should be deleted from the memory. Basically the application should also manage the pattern formation process. The SISs are not supposed to be a single system rather a collection of technologies (Merali et al., 2012), the application listens to the agents as they join and leave the network, when they join, they are registered. The agent register is a vital document for log monitoring and checking agent behavioural content for pattern formation. The SISs has to be a skilful data collector, corresponding to the appropriate knowledge repository. The repositories are data warehouses, which benefit from knowledge exploration and evolution. They process, store and manipulate the data. Whenever an information request is presented the SISs deploys search engines to explore within the defined boundaries, hence deliver
to the right persons or devices as fast as possible. The SISs should be intelligent, they should learn by recording every task they are engaged in, they even should learn their own processes (Tesfatsion, 2003).

Previous complex systems studies have utilized dynamical systems models, among other modelling frameworks to describe transitional state on self-organizing network topologies, with minimal focus on dynamical state changes (Sayama, Pestov, Schmidt, Bush, Wong, Yamanoi, & Gross, 2013). Complex systems exhibit topological transformation caused by preferential attachments or removal of agents. This thesis will demonstrate at an abstract level, that by using the concept of graph rewriting (Generative Network Automata), networks of agents can transition (adapt) and transform (evolve) simultaneously, while seamlessly integrating and presented as a single computational framework, the SISs (Sayama et al., 2013). The graphs state change represents equilibrium attainment, as agents dynamically join and leave the network topology.

2.6 Future Research

In order to evaluate the artefact the study has to generate some results that can be analysed. The study applies the conceptual model in the form of agents in an organization, imitating the known operations of the brain, which this study has used an illustration of a thinking complex adaptive system. Agents are networked computer devices, linked together by computer networks and managed by strategic software applications that explore and exploit knowledge assets (Tesfatsion, 2003).

Buhl, Fridgen, König, Röglinger, & Wagner (2012) have observed a very disturbing trend on strategic information systems research publications. They assert that the publications lose their intended purpose once published. However, these publications keep top managerial decision makers informed on SISs topics. According to Buhl et al., (2012), the problem is rooted in the differences between business strategy and SISs scientific research. While there exists a broader definition of SISs (Galliers, 1993), business strategy is very much linked to entrepreneurial and competitive advantage. According to Porter (1996) and Barney (1991), business strategy involves maintaining a unique customer value that is not simultaneously being implemented by another competitor. The ultimate objective is to outperform the other players in the market. In contrast scientific research is based on inter-subjective verifiable analytical elicitation, documentation, and public dissemination of fully analyzed result. Organizational SISs research results cannot be published openly for competitors to see, for they do not contain anything very unique that cannot be imitated. Information systems experts can replicate any technology if provided with the right requirements. Therefore there is need to improve the means of collaboration between business strategists and strategic information systems researchers, so that there can be implementations of research results in the industry.

For starters, implementers of such desired SISs (knowledge management, creation of intellectual capital), can study Google’s search, storage and dissemination engines, the algorithms involved at Google, MSN or Yahoo, and the process mechanism used. Such studies can assist in drawing organization’s SISs prototypes for knowledge elicitation, exploration, discovery and storage. Google Inc. uses of a program that follows links in a webpage, analyzing all captured data, for pre-specified search. The proposed automated search system is born out of ideas made from learning algorithms such as Google’s. The take away here is that organizations can implement such automated engines to not only search but also learn, adapt to organization’s environmental requirements and evolve in
tandem with organization’s knowledge appetite. Automated systems that conform to complexity science concepts, a new scientific research and implementation front (Desai, 2011). As a closing note, this thesis recommends the use of design science research for this kind of research in combination with tangible results from the natural science field. The concepts of complexity science although well-known at a theoretical level, the interactive patterns of the constituent parts have not been openly drawn, therefore it is challenging to study the patterns (Eoyang, 2004).

2.7 Limitations

Design science research (DSR) is frequently applied to improve the behavioral aspect of information systems. It seeks to expand the human and organizational knowledge boundaries by creating new and innovative artefacts. It is a solution invention research method (Hevner, & Chatterjee, 2010). This thesis is a proposal, a conceptual model for designing SISs. The limitation is the burden of proof whether this proposal is legitimate, it remains to be seen. The conceptual model dares SISs professionals to think out of box for new innovative solutions. This thesis welcomes a healthy debate on the future of SISs design in complexity science concepts. The research for complexity science concepts in has been characterized by limitations of publications on the key concepts, like the emerging patterns of a complex system. This thesis has taken imagination and creativity to steer the study into a thesis, so as to present the main idea to the researchers. Other limitations included the challenges of implementing such a design in the industry, which is among the proposed future research items. This kind of research requires adequate time, it would may be yield better results and even a tangible artefact if combined with action research (AR), additional knowledge from the natural sciences is required (Peffers et al., 2006). The author of this thesis has limited research knowledge, may be the idea would be presented differently if handled by much experienced researcher.

New inventions are always prone to failure. Introducing a new idea is always a risk, especially in the field of strategic information systems, which as observed is rarely implemented in the industry due to the conflicts between the two fields of study, technology and business (Buhl et al., 2012). In this case, the research interest would most probably conflict with the problem solving interests of the organizations. DSR may apply mostly in a learning from failure type of research and development strategy, which requires a lot of trust and funding from the interested organization(s) (Hevner, & Chatterjee, 2010).
3. Theoretical Frameworks

This chapter will discuss three theoretical frameworks that are contained in the proposed conceptual model for the design of strategic information systems. The design is not limited to these frameworks, it allows extensions and deletions as long as the initial idea is maintained. Furthermore, it is just but a proposal, open for contributions.

3.1 Complexity Science

Complexity science is not new (Mukherjee, 2008). Complex systems are characterized by inter-relationships, emergence, pattern and iteration. They contain interdependent sub-structures interacting non-linearly. The complexity of a system arises from its nature of composition rather than the employed rules. Its entire structure spans several scales; consider the case of a multinational company with branches all over the world, which relies on collective data to support management, planning and marketing dynamic schemes. Such is a complex structured company, the branches function to emerge as a unitary structure, managed from the headquarters (Railsback, 2000; Eoyang, 2004).

Complexity science maintains that the world is full of systems, ecological systems, human systems, immune systems, etc. These systems are complex and constantly changing to adapt in their environments ( Railsback, 2000). All computers in a technical system are considered components of that system. A good example that depicts complex systems is bacterial components in flora and fauna ecological system. These bacteria interact and connect with each other spontaneously, from this mass of unplanned and chaotic interaction, regularities begin to emerge forming a pattern that starts feeding back to the entire system while keeping track of all the processes ( Railsback, 2000).

Another example, an electric pole is felled by strong and violent wind resulting to a black out, without electrical energy electronics stop operating, which includes freezers, frozen food will go bad, someone will go hungry ( Fryer, n.d.). The domino effect becomes a continuous complex loop, until when the electricity poles will be fixed, returning the ecological system to normalcy ( Fryer, n.d.). These complex systems are self-organizing; they can go through chaos and disruption only to find their way to normalcy (Mukherjee, 2008).

Complex Evolving Systems

Complex science or complex theory for this matter, consists of two dimensions complex adaptive systems (CAS) and complex evolving systems (CES). They adapt to their environment in a continuous process and they are similar, other than, CES learn from their own evolution process influencing their environment for a new wave of change (Mukherjee, 2008). CES is like a ball of snow, it becomes bigger as it rolls (Railsback, 2000). CES do not have to be perfect, as long as they are better than their competing systems, they are good to go. Once a CES reaches a stage of being good enough, it trades-off its increased efficiency cycle for improved effectiveness. This thesis will discuss CES as an extension to CAS. By doing so, this study will automatically be referring to both concepts without leaving out CAS.

A CES consists of diverse subsets, which are ambiguous and paradoxical. CES exploits
its contradicting composition for new opportunities. Information systems strategically designed in conformity to CES, would create an internal intelligence mechanism automatically, combining network protocols and hardware brands seamlessly, with an additional technical quality. This means an intelligent system can span from organization to organization, collecting any and sundry information that can help the organizational competitiveness (Railsback, 2000).

The manner in which the system agents interact is crucial for maximum knowledge elicitation. The larger the number of agents the better the results (Fryer, n.d.). It is from these networks that connection patterns are formed and a communication validation mechanism is established. The patterns are used for determining which agents to connect to for what purposes. An intelligent knowledge exploration process is established (Mukherjee, 2008). The resultant patterns may be rich in variety, but the rules governing the system functionality are simple. A good example is the world water system; all the rivers, lakes, streams, waterfalls and oceans with all their distributed network and power are governed by a simple principle, that water finds its own level (Railsback, 2000.).

There is no hierarchy or control agent in a CES, all computerized systems can send and receive orders. Neither is there managing or planning of the agents (Computer Systems), thus the need for manual SISs alignment would be taken away. In CES, interaction is unplanned. It happens naturally. The flow of information is determined by the environment (Fryer, n.d.). This thesis proposes a strategic information systems model that learns from its environment, the process should be automatic so that when the system gains new knowledge, it analyzes and processes it for competitive purposes. The new knowledge should activate a solution offering mechanism, a ‘butterfly effect’ that triggers several processes within the SISs. A human agent can only be part of the system, program orders and observe the results (Mukherjee, 2008.). The agents constantly re-organize themselves to find the perfect fit in the environment (Fryer, n.d.). Many nested SIS are smaller systems of other systems, creating complex strategic information systems (Mukherjee, 2008). All the agents behave in an independent manner, as if they don’t recognize their relationship with the other SISs. However, that doesn’t stop them from contributing to the whole system through networks of interactions. The system user does not have to know that the computer is an agent of CES (Auyang, 1998). The most important character of a CES is its ability to cooperate and compete within itself. CES are also open ended: full of open opportunities and possibilities (Mukherjee, 2008; Fryer, n.d.).

The human brain as a complex system, contains billions of neurons with trillions of connections, facilitating complex interactions among electrical charges and chemical compositions (Bucker, Andrew-Hanna, & Schacter, 2008). This human organ sends and receives billion of signals in a second, eliciting actions, calculations, estimations, movement, imaginations, manipulations, all at once. It is possible to predict the actions of a human being, but not with certainty, even a human being surprises itself with some emergent characteristics in time of emergency or shock. Yet, men poses self-awareness which allows them to choose how they interact and relate with the surrounding environment, resulting in patterns and iterations of behaviors. The structure of the human brain follows complexity science, so does ecology, social systems and the immune system. They are constantly adapting, evolving and learning from their environment (Chan, 2001; Bucker, Andrew-Hanna, & Schacter, 2008).

CES are models for computer thinking and predicting what will happen. CES has the
intelligence to learn from its previous evolution processes, analyze all the occurrences and predict the probability of repeats. Organizations that have the capability to build complex evolving information systems can benefit from computer aided decision making, therefore avoid making bad economical, managerial and planning decisions (Dandridge, Laporta, Chauvet & Papamichael, 1999).

The modern capitalist economy is made up of intertwined industrial behavior of consumer and financial markets, which form a complex system. The overall pattern looks chaotic, the same pattern is seen in the neurotic interaction. In the brain billions of neurons interact to produce a complex behavioral pattern, so are economies (Mukherjee, 2008). This thesis suggests that SISs should be designed to conform to the complexity concepts of learning, adapting and evolving. This can be achieved through organizational alliances for knowledge sharing, a network for like-minded firms. The resultant SISs should be able to caution the professionals and executives for a sustainable competitive advantage mechanism.

Complex Adaptive Systems

Figure 2. Representing the process of pattern creation in a complex adaptive network system (Fryer, n.d.).

Figure 2, represents a computational feedback mechanism that takes in information from interconnected agents, processes it, stores it in patterns format and uses the patterns as a validation tool for the systems processes. Requests are send from the computational environment, to the memory storing the patterns, so as to validate knowledge and processes, if the patterns do not match, they store the new pattern and generate a report to inform the user. Autonomous computer applications process the information, for intelligent gains, information entered from different networked systems in multi-disciplinary departments in the interacting environment.

CAS is similar to CES other than CAS does not learn from its process or environment, it is composed of interacting agents. Learning is defined as acquisition of knowledge
(Oxford dictionary, 2013). CAS is not able to learn from its own processes (Fryer, n.d.). CAS diversity determines its complexity, the larger the number of networked agents, the larger the interaction, and the harder it is to predict the system’s next course of action. CAS creates knowledge when it senses the relationship between the stimuli and the response, it then interprets future situations using the patterns. CAS relies on previously established contact relationship for environmental adaptation. However, CES recalls even in a terrible chaos scenario CES will attempt to deploy one of its patterns to impose a solution (Sherif & Xing, 2006). Strategic information systems designed conforming to CES would recognize and interpret a repeat occurrence, if it had occurred before. Consider this example: in case a financial officer repeats a bad accounting practice previously executed and recorded as bad through an intelligent application (SIS), the system would recognize the act and generate report to warn against the execution. However, with CES it learns automatically, there being no need to program an application (SIS) to recall history. CES learns through the interactions, the system would automatically evaluate all acts of executions throughout the networked system to deduce the process on consequences of the financial officer’s act, therefore generating a report to specified personnel. Basically, it all involves a software application (SIS), either installed or embedded in the system. The main difference between the two is that CES designed application (SISs) requires more innovative in code. A CES application would be programmed once and for all, there would be no need to keep on keying-in orders and rules. A CAS designed application requires entries to inform it about decision that were made and turned-out to be bad so that the application keeps an eye on repeat actions. The SISs software applications would be designed to keep track on all computing processes, they are programmed to detect processes that lead to loses and archive them as “bad practices” patterns. The patterns are then used for comparing every computing process to determine the process status (good or bad). When the system explores for knowledge from out there, the software application is used for determining the knowledge’s destination in the repositories. The software application then fetches the new knowledge and sends it to the right personnel for action, that way the organization is able to detect market situations, customers’ needs and anything else that may concern the organization.

CAS knowledge creation is governed by several mechanisms, among them tagging, which allows interaction between agents. Tagging is a process of labelling for the purpose of identification (Oxford dictionary, 2013). Agents initiate collaboration requests to execute complex tasks depending on the tag attached. Besides interacting, agents agree on different rules of engagement in line with the normal protocol, in order to enhance their performance. For example, agents may link, combine efforts and assist with vital information in the wake of a complex request. Agents also mutate with time, restructuring to fit their environment, so as to offer the best of solutions, they specialize in conformity to popular triggers (Sherif & Xing, 2006). Agent applications can be designed to learn and specialize from common orders, from the nature of banked information and its surrounding networks.

Agents are always ready to answer any triggers, when a request is sensed all agents scramble to sniff it, in an attempt to offer a solution. The process of sniffing can easily generate confusion, causing a system over-load due to many solutions offered, while some agents get trapped in an over-lived solution span, they keep on offering solutions to an expired order. (Sherif et al., 2006) called this phenomena credit assignment. Solutions compete on their level of accuracy and uniqueness in relation to the order, the value of the solution depends on its specificity and fitness improvements. The ability of agents to offer improved solutions induced by the past experiences is informed by
exploitation and exploration mechanism, as agents encounter new scenarios, they gain new experience, hence improved solutions. (Sherif & Xing, 2006). In evolutionary theory, the immune system becomes stronger with every new attack (Liu, Dang and Wang, 2006). SIS applications and systems have to be designed so that they utilize the intelligence gathered over time, the trigger responses serve as strategies that define the level of competitiveness. Intelligent responses translate into quick and informed decisions to avert crises, the rapid solution, warning and advice mechanism determine the position of an organization in a competitive rugged terrain (Merali et al., 2012).

Agents systems ought to be loosely coupled to allow long jumps into the neighborhood to explore new situations and solutions, to allow free learning. The agents interact and self-organize automatically, as the situations changes (Sherif & Xing, 2006). The SISs application should possess elastic tentacles, more like an octopus, able to connect with numerous neighboring agents at the same time, learning and acquiring new knowledge. Moreover, this thesis has utilized generative network automata graphic representation to demonstrate how networks can achieve dynamic re-alignment as agents join and leave the network (Sayama, et al., 2013).

3.2 The Network Paradigm

A network is a mesh of nodes and links, the links can either be directed or undirected, weighted or un-weighted. The brain contains a huge network of linked neurons (nodes), human beings are nodes in social networks, linked by relationships. In this context we focus on organization networks (SISs) that create “network thinking” by knowledge sharing which is synthesized by an intelligent software application (SISs) for competitive advantage (Mitchell, 2006.). Both the network and the application are SISs in this context, designed to conform to CAS patterns, just like neurons in the brain (Bucke, Andrew-Hanna, & Schacter, 2008). The strength of the network remains in its ability to exhibit reliability.

The increase in number of agents inside and outside the organization’s system demands complex architectures, reliable connectivity and access to knowledge repositories (Merali et al., 2012). Increased inter-organizational collaboration creates opportunity for connectivity. Emerging technologies have enhanced communication facilities, transforming the world into a digital village. Slight changes in one corner of the globe can be transmitted within seconds to the end of the other, influencing social life, politics of the day and regional economy (Merali, 2006; Merali & McKelvey, 2006). Connectivity is critical for acquiring knowledge and intelligence for competition, important for dynamism to facilitate among other things: learning, innovations and quick decision making (Merali et al., 2012). While some researchers support knowledge exploitation, some advocate exploration. Exploitation takes place within the organizations’ repositories, while exploration spans across network platforms, beyond organizations boundaries. Exploration is touted as the source of new knowledge (Abebe & Angriawan, 2013). Merali et al., (2012) believe that organizations will find it very hard to isolate themselves and their resources from the environmental changes, if indeed they are looking into complex system thinking. Complexity science is built on the foundations of co-evolution, its concepts are affected by their surrounding environmental dynamics. (El Sawy et al., 2010) advocates for definition of patterns arising from CAS in understanding the way to design SIS. The patterns are unfolding interactions from a network of agents in the competitive environment. Following El Sawy et al., (2010)’s idea, networks between organizations play a big role as complex SISs, considering organizations as agents. The network paradigm adopts co-evolutionary strategies in this context for viability purposes so as the inter-connected
organizations can adapt and evolve, continuously and simultaneously develop new capabilities and relations that well augur with the changing opportunities (Merali et al., 2012).

The network paradigm shifts the view from the mother organization into focusing on network of firms: Network for opportunity creation, strategic industrial communities the so called “digital villages” or “economic zones” (Borgatti, & Foster, 2003). This study entertains this idea because complex systems (CAS & CES) cannot exist in isolation. If organizations want to benefit from this complexity approach, they have to open their systems to a defined radius of partner organizations. Dynamism in competition requires agility, resource and organizational configuration in co-evolutionary mechanism, to keep up with demands of a changing competition landscape (Tanriverdi et al., 2010).

While this thesis wishes not to delve into economic reasons for organizational connectivity, it certainly understands that the pace of change in a competition environment can be too fast for a single organization to handle the cycle of dismantling existing SISs infrastructure to create a new sources of competitive advantage, which can be wasteful as well. For such reasons, this study suggests a network of organizations, anchored on the premise of resource diversity, strength, distance and longevity, in a constellation that fosters adaptive potential.

**Connectivity people & devices**

Knowledge creation in the organization involves, among other mechanisms, exploration and exploitation of already existing knowledge, a rigorous selection process. It involves a mechanism for searching, preserving, reproducing and constantly informing of the existing knowledge to the relevant authority. Just like CAS, the challenge is to integrate and synthesize varying specialized knowledge. The process of creating intelligence from existing knowledge depends on the information assets packaging process used. The packaging process facilitates interaction and information pollination across the network domains. The professionals who create knowledge, package and use it are a part of CAS themselves. Information gained from different projects over time is stored in organization’s repositories. However, captured experience may not add any value, if it does not impact the organization’s performance against challenges. Most firms lack mechanisms to extract the information for use at the right time, for the right purpose. When organizations are faced by uncertainties, the time between failure and recovery is crucial for competitive advantage. When faced with challenges, agents automatically assess their knowledge repositories and identify stored solutions for potential response (Sherif & Xing, 2006).

The repositories are elastic, they continually feed on new information, delete duplication and self-organize. Organizations have different knowledge assets, which are divided in accordance to departments. Repositories also share a common connection to each other. They are networked. To create new intelligence, SISs software application(s) have to be developed to manage the relationship between the knowledge assets and agents. SISs developed in conformity to complexity science should have the capability to release the knowledge assets outside their mother network (organization). Different networks belong to different organizations, where professionals have different schools of thought. The other organizations may have different information that the firm lacks, organizations develop their SIS in response to their objectives and goals, which may be different from one another. Thus, different intelligence sharing (Sherif & Xing, 2006).
New intelligence can be created from organizational repositories by exploration and exploitation and exploration, the more the knowledge assets the higher the chances of acquiring competitive intelligence. Like CAS, an organization should conduct inquisitive experiments to ascertain the benefits of knowledge sharing and borrowing, to reduce risk of loss.

All strategic information systems interact forming a networked structure of micro systems. The fact that they encompass human users mean they become coupling a structure, because human beings represent another complex system, inter-connected by the environment.

The information systems network can span from organization to organization. With powerful routers and sound network architecture, connectivity can be limitless. The network consists of diverse populations of technological possibilities, client platforms, service providers and user groups. All representing knowledge assets for the business intelligent servers (Merali et al., 2012).

Business competition in a rough terrain requires firms to be agile and manage their resources and the organization in a co-evolutionary manner (Merali et al., 2012). The network is measured in-terms of radius of span. System networks go beyond the organizational boundaries connecting with others, in pre-defined adaptive relationships varying in strength, longevity and nature (Merali et al., 2012). This means building links with both friendly and competitor organizations, defining what resources to allow beyond the demilitarized zone, what to share, what to give and what to acquire from the others.

Another fundamental issue is organizational positioning; the firm becomes a component in a multi-dimensional, level structured competitive sphere. And the real dynamics of the relationships emerge from the interconnected components. The problematic issue arises from intelligent information acquiring. If the firm cannot align its resources in clearly due to the so called ‘rugged terrain of competition’, it stands to lose. Other firms may deem the relationship fruitless also, if they can’t benefit either (Tanriverdi et al., 2010). However, the main objective of the connectivity and relationships is not obscurity, rather open-ness (Merali et al., 2012). Therefore, this problem should never be mentioned in the same breath as SIS in CES.

This issue introduces the Open Source Factor in this equation of SIS design and implementation ‘Development’. Otherwise the challenge would be to determine the right strategy for exploring the competitive landscape of shared information, for organizational benefits, identifying the rich grounds, other than blocking each other (Merali et al., 2012).

Complex systems are networked systems, they are open, rugged, composed of many sub-branches and levels, they are heavily interconnected through different levels of linkage, and the nature of this networked body of worldly systems makes it unpredictable. A small input in the remotest small link can cause a major ripple effect to the whole system and its outputs. These systems can adapt and transform within a very short time (Merali et al., 2012).

These are the characteristics which should be added to the SISs, for organizational benefits. The speed of reshaping after a major incidence is determined by the micro constituents of the entire system. For example, if the organization incurs a heavy loss
through the stock exchange, a change in the value at the company’s share on specific exchange like DAX, NYSE, etc., the SISs can adjust the entire accounting system, reflecting the deficit with alarm indicators. Because of its evolving capability it is able to re-align all priority activities for the finance department, generating reports for the necessary personnel to make the adjustments, like cancelling unnecessary spending and cautioning on any extra spending. Profit can be attained by cutting spending as well. Any organization with such a SISs can realize economic advantages faster than the competitor (Merali et al., 2012).
Networked Organizations

Strategic partnerships are very popular nowadays. Organizations form defined relationships that rely on trust so as to cut cost and protect their transactions, in a spirited fight against forces of competition (Borgatti & Foster, 2003). Due to international commerce, competition has received a new meaning as the markets become more turbulent and unpredictable (Merali et al., 2012). The market harmony created by the traditional trading dynamics has been destroyed, in place, a networked system of organizations emerged, in a bid to create mutual protection (Borgatti & Foster, 2003). Many of these relationships have been based on financial, market and tangible resource sharing, few on knowledge sharing, (Sydow & Windeler, 1998). This study seeks to open-up organizations’ alliances to the world of competition. In future competitiveness will not be achieved by obscurity, rather by openness, the foundation of organizational success will be erected not on protection from perceived competitors, but on knowledge acquisition (Halonen, 2012). Competitiveness will be measured on the quality of intelligence acquired, firm alliances will be formed to share knowledge (Merali et al., 2012), for innovation, quality production, quick and timely delivery, customer satisfaction and quick recovery (Sydow & Windeler, 1998). Over reliance on old business strategies like board interlock and business mergers has lead organizations to unprepared dissolutions (Borgatti & Foster, 2003). There is need to strengthen organizational readiness through other innovative means, like the use of information systems to build rare strategies, for competitiveness (Borgatti & Foster, 2003).

As this study mentioned earlier SISs can be an application, hardware or even a network structure. Networks are supply chains, they enable organizations to send and receive information. Networks enable interactions between organizations, as networks spread they enable learning and adaptability in the environment (Sydow & Windeler, 1998). Networks are highly nonlinear systems, exhibiting complexity and unpredictability (Sayama, et al., 2013). They evolve and self-organize with time, forming elaborate structures and patterns while connecting many knowledge repositories as many organizations join the alliance, in essence changing the environmental dynamics (Merali et al., 2012; Li et al., 2010). These patterns and structures can be learned and stored for the purpose of comparing and evaluating knowledge sharing trends, they can enable detailed sieving of available information, aiding in strict search for vital knowledge for competitive advantage (Li et al., 2010).

To better understand how networks evolve and adapt, information systems researchers have to examine the complex nature of the interaction from an evolutionary angle. They need to look into the factors and principles governing behavior patterns and structural emergence of networks (Choi, Dooley, & Rungtusanatham, 2001). Wilkinson and Young, (2002), observed that behavior patterns and network structures emerge in a bottom-up self-organizing way. Li et al., (2010) concluded that researchers had done very little understand the dynamic structures, behavior patterns and evolution of networks as complex adaptive systems. Li et al., (2010) still noted that the available studies had been theories, derived from multi-agent based models and simulations. Nevertheless, with respect to their argument, this thesis took to agent based modeling to explore varying emergent network behavior patterns, in a bid to understand how networks evolve. Agent architecture has been researched by many institutions, and there are numerous articles supporting this statement, the resolve was justified by the sheer weight of the published content.
Adaptive Networks

All the agents in adaptive network interact with each other in a continuous motion, generated by the environment agent to fulfill the demand (Surana, Kumara, Greaves, & Raghavan, 2005). The topology in complex networks keeps on evolving, they constantly interact with each other due to the systems dynamics (Sayama, et al., 2013). When the structures of the network coevolve with the dynamics it leads to self-organization, so that the topological properties of the network rests on a critical point, where dynamics change qualitatively (Christensen, Donangelo, Koiller, & Sneppen, 1998). Bornholdt and Rohlf, (2000) borrowing from (Christensen, et al., 1998) suggested another model in which self-organization would be understood in detail. Their work demonstrated that dynamism on the network topology effectively explored the network structure making all necessary information available to every agent. The information fed the evolution process, activating the critical state of dynamism.

Borrowing from Bornholdt and Rohlf, this section focuses at the self-organization topic. Arguably, any information processing system should be in critical state, there is a big probability that the brain resides in criticality (Sayama, et al., 2013.). Bornholdt and Rohlf in their paper presented the perceived brain mechanism on criticality, which they further supported with experiments (Beggs & Plenz, 2003; Kitzbichler, Smith, Christensen & Bullmore, 2009). Biological scientists have already utilized self-organizing criticality to understand the neural functionality in the brain. Adaptive networks have played a major role in developing this scientific front, which has led to new diagnostic tools in medicine. This discovery holds the key to design and development of self-organizing adaptive information systems (thinking systems) (Sayama et al., 2013). Self-organization can occur when network structure and agent states evolve simultaneously, this has been researched in detail by (Gross, Dommar D’Lima, & Blasius, 2006), in epidemiological models. Their study’s objective was to provide a thorough analytical investigation into the emergence of system-level process from agent (node) level coevolution. Their model remains the benchmark for performance analytical approximations to adaptive networks Sayama et al., (2013).

There exists several models whose results support the hypothesis of adaptive strategic information systems. If deduced, the processes can be replicated into building artificial complex adaptive systems, what this thesis calls “thinking systems”. For example, Holme, Newman, Zanette and Gil, (2006) published opinion formation models in 2006, arguing that coevolution dynamics eventually lead to fragmentation transition, that describes the assimilation and diffusion of competing opinion. Agents facilitate transfer of knowledge from one repository to the other, sometime interacting outside the organizational boundaries into shared repositories. At this point, agents are carrying different and conflicting information, following opinion formation model, the agents can diffuse their contents in the process of evolving to create new knowledge. The mathematical model of opinion formation has been severally criticized, that it does not meet the threshold to be considered as a process for complex opinion formation in reality. However, Centola, Gonzalez-Avella, Eguiluz, and San Miguel, (2007), investigated an agent-based adaptive network model, of cultural drift finding similar results as Holme et al., (2006), therefore putting to rest the argument while validating the phenomenon.

For the purpose of clarity this thesis although abstract will borrow from the Sayama et al., (2013) illustration of an adaptive network mechanism. They used graph rewriting systems to represent the network structure coevolution, which they called Generative Network Automata (GNA). GNA is a network made of directly linked agents, their models also can represent undirected links using pairs of directed links between agents.
Agents are denoted by a pair of nodes state $S$. The links represent relationships between the agents, denoted as $S'$. Combination of states and the network structures is a configuration of GNA at a given time ($t$), description is listed below;

- $V_t$: A finite set of agents at a time ($t$). This is an unstable set in GNA framework. It can change any time, due to changing numbers of agents.
- $C_t: V_t \rightarrow S$: the vector denotes a global state assignment on the network at ($t$).
- $L_t: V_t \rightarrow \{ V_t \times S' \}^*: A map of a set of agents to a sent list of destinations, the link state, $S'$ is a link state set. This vector represents the global topology of the network at specified time ($t$). The states and the network structures of GNA keeps on updating and rewriting events.

**Figure 3.** Representing GNA rewriting process of network structures (Sayama et al., 2013).

Figure 3, depicts GNA rewriting process, as presented by Sayama et al., (2013) paper;

a) The extraction process $E$ selects a part of GNA  
b) The replacement $R$ generates a new subGNA and also specifies the interaction between old and the new agents (dashed line)  
c) The new subGNA generated by $R$ is embedded into the rest of the GNA structure  
d) The resultant GNA after rewriting

Therefore GNA can be simply defined by the following triplet [$E, R, I$], listed below:

- $E$: Extraction  
- $R$: Replacement  
- $I$: Initial configuration of GNA

The functions of extraction and replacement of knowledge can be defined either as deterministic or stochastic. Stochastic is defined by Oxford dictionary as having random probability distribution or pattern. A stochastic representation of a GNA algorithm will be fundamental in real-world application, for example in complex data network formation, in which random fluctuations and errors are inevitable (Sayama, et al., 2013). Algorithm $E$ (subGNA extraction process), allows flexibility in network evolution and a clear map in simulation computational and or application development. The GNA algorithm makes it easier to depict the preferential attachment mechanism used in network science to implementing scale-free networks, as it is hard to represent such systems using graphs and grammar. Application of GNA is characterized by constant
updating of the network topology, for asynchronous automata networks can replicate any synchronous automata networks (Nehaniv, 2004). GNA algorithm can implement all dynamics that can be produced by any network model (Sayama et al., 2013).

Figure 4. Representing GNA simulation network structures (Sayama et al., 2013).

Figure 4, shows some of the dynamical network structures that can be achieved by GNA simulation (Sayama et al., 2013). These shapes have been achieved through Wolfram Mathematica, following the format \([E, R, I]\), asynchronous random Boolean network \((N=30 \& K=2)\), time flow (left to right), asynchronous 2D binary cellular automata by Von Neumann Neighborhoods and local majority rule. Agents are non-homogeneous in random Boolean networks, they follow different transformation rules. Each agent transformation being embedded as part of its state, which is referred to by replacement mechanism \(R\) when calculating the next state of the agent (node). Each new agent is attached to the network structure with one link, extraction process \(E\) is implemented to determine the place of attachment based on the agent degree, causing the creation of a scale free network (Barabási & Albert, 1999). GNA modelling framework can yield
many dynamics, Sayama, et al., (2013) conducted several computational experiments to attest this. This study has just portrayed in brief that it is possible to build adaptive networks, that degenerate whenever an agent join and leaves the network topology.

3.3 Open Data Strategy

For Strategic Information Systems to be implemented successfully in the complexity paradigm, organizations have to adhere to openness, thus open data sharing. The open data sharing has so far been successfully practiced within governmental and scientific sectors only; health facilities in many European countries are sharing patient data already (Fioretti, 2010). Fioretti, (2010) advocates for wide spread use of open data strategy in private businesses. By doing so, small and medium businesses will benefit from the available public data sharing. There would be more employment and revenue contribution into the economy, and especially in these trying financial times (Fioretti, 2010).

Open Data is more of a movement as in Open Source; it is a state of mind as much as it is a practice. Even though in Europe it had existed for years along e-Government, it gained more popularity and recognition in 2009 after US Government adopted the stance, ‘The Transparency Directive’ (Bauer & Kaltenböck, 2012). The idea is to establish close cooperation among public administration, industry and citizenry, through information sharing in an open manner, enabling transparency, participation and collaboration for development. The enabler is free access to data and content, free manipulation and modification of information through computational devices, thus information systems.

Open in data means removing barriers to accessibility of information for progress and development, allowing use and re-use of data and information. Among the principles of Open Data, as formulated in 2007 at Sebastopol, is freedom from prohibitive costs and obscurity, making the whole idea an Open Source Movement (Bauer & Kaltenböck, 2012).

In Finland for example, public data sharing has been successful to some extend although it could be better (Fioretti, 2010). Most activities in this part of the EU comply with Infrastructure for Spatial Information (INSPIRE) Directive 2007/2/EC, which advocates for open sharing of public data. For example, if a car was repaired in Helsinki in a registered garage, the repair information will be visible in a registered garage in Rovaniemi. The advantage here is not only limited to efficient sharing of information; it provides a strategic advantage to the registered garages, which receive the data from administrative servers through Katsastus (a network of authorized vehicle inspection centers). The entrepreneurs manage to stay ahead of the competition by applying Strategic Information Systems (SISs). The geographical disparity defines the magnitude of the system into a complex system. A car owner will always choose to take the car to a registered garage because the car information is distributed all over the country, allowing for consumer freedom.

The Katsastus network of Information Systems (ISs) is a good example of a Complex Strategic Information Systems (SISs). Every day, new information enters the database, the database creates more space automatically, either by expanding or discarding unnecessary data, thus adapting to its environment. Every now and then the computer system learns from the previous information stored in the server. For example, if a vehicle exceeded maximum carbon dioxide limits last year, the information systems infers that the vehicle’s road worthiness cannot be extended this year, unless the engine
was changed, of which the computers would know already. The information system therefore issues a penalty ticket to the car owner and generates a vehicle report to justify its action. That makes the information systems a complex evolving strategic system. Apart from adapting to its environment, it learns from its processes as well.

Fioretti, (2010) likens releasing public data to small businesses to stimulus money or giving lobbying power to these businesses. However, to release and share data with other organizations requires a strict code of conduct. For SISs to work successfully in a complex paradigm, data must be shared efficiently and effectively. For that to happen, there must exist a concrete modus operandi between the organizations, or the parties must agree to share the data in an Open Source manner (Halonen, 2012).

In February 2011 the UK government launched an open data system, through the cabinet office, dubbed ‘Contracts Finder’. The aim was to extend a strategic value to the small scale businesses and start-ups through information systems. Giving the businesses a single portal where they could find all government tenders upon sign-up, the venture was successfully attracting well above 97,000 views per week by April 2012, holding £70 billion worth of data (The Ministry of State for the Cabinet Office and Paymaster General UK, 2012).

Manyika et al., (2011) considers Data to be the new capital for the global economy, and as organizations seek growth, customer satisfaction and stronger performance the need to exploit data is higher. Big companies like Google Inc., Facebook, Amazon and eBay have taken advantage of available data to create most profitable business ideas in the world. There is a constant increase of data volume and technologies out there, ready to be collected, stored, managed and utilized (Deloitte, 2012). However, many businesses have a wrong imagination about open data, they see it as a governmental thing, a technique to put data out there for the purposes of transparency to the public (Manyika et al., 2011; Halonen, 2012; Deloitte, 2012). In essence open data in an increasingly burgeoning data system. Open Data are publicly available resources, some contributed by the government, businesses and citizens. The available free information out there is enough to trigger an attitude change in businesses, towards open data (Halonen, 2012). There is enough open data for every business in every industry, sufficient to improve their products and services (Deloitte, 2012).

Open data means businesses allowing access to public or to a community of participants, including competitors (Manyika et al., 2011). The data must be available free of charge, even for commercial purposes. So far many business have opened their data to some degree, even without their knowledge to this fact (Deloitte, 2012). This proves that the challenges of opening up are not technical but cultural, there is fear of losing more than gaining, most businesses focus on the fact that they lose more than they gain (Deloitte, 2012). There are several advantages for opening up to other businesses, among them;

- To obtain intelligence on competitors
- To increase integrity and fidelity to own data
- To support industrial communities, growing together
- Sell data related services and gain more knowledge on customers
- Improve collaboration within an industrial park
- Demonstrate transparency, build trust and improve reputation
- To obtain crowd source solutions and improve data quality
- Create a social engagement platform, which can assist in attracting scientific talent
- To create data reuse

Complexity science concepts form the basis for the tentative conceptual model for SISs design. Network paradigm is a vital component in understanding the interaction between systems and the organizations. Open data is proposed as a concept for solving knowledge sharing challenges. The author advocates for open data sharing, as some organizations may have dilemma in determining which information is fit for share and which information should be hidden from the public. Industrial collaboration cannot progress in seclusion and obscurity, the future of inter-organization knowledge sharing will depend on organizational readiness to release internally held information for mutual benefits (Halonen, 2012). The conceptual model is made-up of individual agents, operating alone, and forming interactions according to their own need. However, they join to form the entire whole unit as SISs, conforming to complexity science concepts. The conceptual model advocates for a distributed design model, the agents are located on different locations and in different organizations, interacting through the network, where agents join and leave the structure at will. The model has provided a zone for a depositing data, the so called “shared repository zone”. Some organizations may have challenges in sharing their entire data with the other organizations, the shared repository zone provides such organizations with a convenient way of depositing data that they’re willing to share with the others. In-turn such organizations can only benefit with a limited data provided for them through the same mechanism. However, the conceptual model, calls for open data sharing. Organizations stand to benefit more, if they can release their data openly, for competitive advantages do not arise by holding crucial data, but by utilizing the knowledge gained. It is the innovativeness of the SISs implementation and the organizational management and decision taking that determine the level of competence.
4. Case Study

This thesis posed a question, whether it was possible to design an automatic strategic information system, which can learn without being programed. In simple terms is it possible to automate knowledge assets by linking them with organizational business strategy, to create new intelligence as a competitive weapon? This thesis has attempted to prove that it is possible to achieve such intelligent SISs through emulating the concepts of a complexity science. A lot of success stories have been published about organizations that achieved their competitive edge through knowledge management and strategic alignment (Buckman, 1998; Davenport & Volpel, 2001). This study case is about an international India firm that designed and implemented a distributed SIS for competitive advantages. The case is about changing an old dysfunctional SISs to a modern system that is aligned to business processes, portable, scalable (accommodates business growth & changes), learning and predicting the future for the firm (Chatterjee & Watson, 2005). The new system connects the firm’s branches to the headquarters in Bangalore, and customers from around the world.

Infosys Technologies was founded in the early 1980s by a group of computer engineers, its objective was to be a major player in software solution market. In 1990 it registered an IPO offering, raising enough funds to expand its operations in Bangalore, by 2002, Infosys had over 10,000 software professionals’ employees and a revenue of over $540 million (Chatterjee & Watson, 2005). The company has several branches around the globe, including several sales headquarters in the United States (US). Its sales team comprises of the business development managers (BDMs), responsible for sales prospecting and generating clients and business for the firm. Each BDM is assigned to a specific territory and is responsible for business growth there, reporting to the regional manager (RM). RMs oversee a large geographical area. The delivery team in Infosys is divided into strategic business units (SBUs), which are organized in-terms of a region or domain specific. The firm has accounts managers (AMs), for large accounts. AMs are located at the client’s site and the face of the offshore delivery team, they are among other responsibilities, tasked with maintaining the firm-client relationship (Chatterjee & Watson, 2005).

Infosys had an information systems department, comprising of 150 professionals, which was facing challenges in handling the technological needs of the technologically-savvy company. The demand for a dynamic information systems was high as its systems design requirements kept on changing all the time. The Information systems in Infosys kept clients waiting, over the years the IS systems had been an inherent necessity at the firm, they had managed to transform business processes all those years. However, they needed to be changed to align with the firm’s new status. The IS department was divided into small groups that were attached to different departments, for example finance department had its own IS experts serving it, so was the sales and human resources departments among others (Chatterjee & Watson, 2005).

Infosys success was based on its ability to deliver low-cost and high quality solutions, made possible by its global delivery model (GDM) that relied on geographically dispersed teams, which divided their work suitably. The teams coordinated their work processes simultaneously and seamlessly, despite working in different time zones. The GDM was the backbone of the firm’s strength in global presence and efficient offshore
development teams, it enabled time, quality and value delivery to the customers. While GDM was seen to be a success, it heavily relied on human coordination, communication and collaboration. Sometimes, the support systems facilitating such processes of interaction and information sharing were inaccessible or had integral problems. At times the onsite personnel at the client’s site had to rely on fax and telephone to communicate with their counterparts. There were data accessibility problems, systems failures were so common that even the existing customer relationship management system (CRMX) was not integrated with the back-end delivery systems. Such integration problems affected the sales teams from responding to queries from clients, losing business opportunities and customer trust all together (Chatterjee & Watson, 2005).

The CRMX systems had to be replaced with more powerful and integrated CRM platforms. Innovative and intelligent systems were essential for the future success of Infosys. The CRMX was once an innovative product, then it was easy to deploy and relatively inexpensive to buy and maintain. However, the system was static, it also had no room for the expanding Infosys. CRMX had started losing its usefulness with time. Primarily it created a data island in the firm’s repositories, its knowledge base could not be accessed, and neither could it be shared due to compatibility and integral issues. And also the system turned to be expensive as the days went-on. The system had a complex security system which was outdated. It also had to be installed on every user computer, consuming unnecessary man hours. Among other reasons why CRMX had to be phased-out included its lack of adaptation to the firm’s processes, the workmanship had changed including the human resources, young employees found it difficult to handle. It also lacked Web-based access, mobile users could not use it (Chatterjee & Watson, 2005).

Finally the decision was reached to change the system into a more robust, adaptive, evolving and learning systems. Before changing the old system the firm carefully analyzed it, as was the standard procedures in Infosys. The change initiative was named “foCus”. The team formed to oversee the change had great representation from all department and all levels of users. As the requirement elicitation process took shape, it was clear the responded wanted an integrated, fast and cost effective systems. They wanted a new system that enabled knowledge and expertise sharing from all departments, realizing synergetic benefits. They wanted to eliminate data duplication in the firm and create data redundancy. Generally they wanted an information system that could led to opportunity identification, proposal generation and submission, contract finalization, real time interaction, project set-up, software development and delivery capabilities, they also wanted an application that allowed expansion in-tandem with the organization’s knowledge assets. The ultimate goal was to implement a scalable, dynamic and a long-term platform that would integrate all aspects of business, from marketing to product development to delivery and customer care (Chatterjee & Watson, 2005).

In the end there were people who felt it was very risky for the firm to invest in such a complex platform, they felt it might turn-out to be an expensive affair, a “white elephant” project that may never get completed. In the end of stakeholder’s arguments, a vote was cast and the decision to develop a new system was passed with a slight margin of two votes. “CIMBA” team was formed overnight and the development work started in earnest, the system was named; customer information management by all (CIMBA). CIMBA offered more comprehensive capabilities, including knowledge management, sales revenue forecasting, real-time data sharing, superior data synchronization, and access control and loss avoidance from unauthorized projects (policing capabilities) (Chatterjee & Watson, 2005).
The firm decided to develop a proto-type first, which took six months. While designing such an integrated CRM platform seemed like a great idea, transforming it to a reality was almost a nightmare (Corner & Hinton, 2002; Kenyon & Vakola, 2003; Schmerken, 2003). The firm had never before developed such a complex software, it was not only going to be used in India but globally, it had to be integrated with other seven applications and the new system would be in use 24/7, through-out. Furthermore, the developers chose XML, a technology that they were not familiar with. They had to learn it in four days and a week of practicing it. CIMBA was among the most complicated systems of that time, it integrated data from many geographically located repositories. By mid-2001, the first phase of CIMBA was completed, it was first rolled-out to a selected pilot group in American braches, the response was very positive, even though they were small amount of bugs. The second phase was integration with existing application, there were minor agreement problems, but they were ironed-out successfully and phase two was completed in a record time, one month. By December the same year the project manager announced that CIMBA system was ready for delivery (Chatterjee & Watson, 2005).

Today the platform still experiences some challenges but they are always sorted, even though they anticipated these problems. CIMBA is a great SIS, however, it has not been to predict the future for Infosys budgeting purposes as the developers had anticipated. They could have implemented an algorithm for process learning, a feature that was not mentioned during requirements elicitation. CIMBA is able to adapt and evolve, the system is distributed across the world and can function real-time, simultaneously and seamlessly. CIMBA constitutes many parts that contribute to the entire process, it is an integrated system, and Infosys modified and incorporated seven old programs with CIMBA. Infosys case was chosen because it fulfilled the requirements of a complex SIS, the case was imperative to demonstrate that the industry was already thinking towards complexity science concepts (Chatterjee & Watson, 2005).

The case study revealed that implementing strategic information systems as an integrated and distributed system is helpful to an organization. For the system is able to acquire knowledge from many different sources. Complexity science concepts are integrated to form a unitary system, tiny individual processes integrate to make the whole. Additionally, a complex system feeds from different sources for survival. These concepts can be analyzed for benefits of the SISs design, for development of skillful, effective, efficient and sustainable systems. Even if the case still exhibited some failures, we have to admit it was among the first, of such distributed systems, it was an ambitious project but it was largely successful. Following the tentative conceptual model in this thesis, the CIMBA system conforms to the principles of complexity science, it is a distributed system, the agents are located globally, they interact through the network to accomplish processes, the system is able to combine knowledge and provide some informed prediction about the future of Infosys. The system is scalable, it creates space to accommodate the system expansion in the future, because Infosys is a fast developing organization. The Infosys system accommodates its clients, the design factored in the need for environmental interaction. Client’s systems are integrated into CIMBA, clients are able to give real-time orders, comments and feedbacks. Clients are also able to monitor their orders and Infosys is able to track its deliveries. Infosys filed personnel are able to access the system from mobile devices, a mechanism that demonstrates the network dynamism. However, CIMBA is not able to learn from its own processes. This thesis views that limitation as a starting point for the next research, rather than the end.
5. The Results: A tentative conceptual model for designing distributed SIS

Business strategy and information systems (ISs) seem to be distant topics, their relationship is of great importance for business and academic world (Pijpers, Gordijn, & Akkermans, 2008). Henderson, Venkatraman, Luftman, Papp and Brier were among the first developers of test frameworks for understanding business strategy-IS alignment (Pijpers et al., 2008). However, their models offer abstract information to aid alignment reasoning, but no clear guideline on how to align both concepts during the design phase. Additionally these frameworks concentrate on internal alignment, within the organization. These frameworks do not focus on how the organization’s systems interact with their environment, yet web is a vital infrastructure in today’s business world (Pijpers et al., 2008).

To overcome the challenges of alignment this thesis proposes a design model (see fig.5) that capitalizes on complexity science known concepts of self-organization, adapting, learning and evolving. The model seeks to enhance SISs performance, as an automated system, where agents interact freely feed information to each other and emerge as a whole with a single purpose. The tentative design can be used for exploration, exploitation and management of knowledge within and without the organizational boundaries. The model enhances organization and environment interaction, it encourages organizations to form knowledge sharing strategic alliances. The model also advocates for open data concepts, for competitive advantage may not be etched on the information but on how that information is utilized (Merali et al., 2012).

![Conceptual Model for Distributed SIS Design](image)

Figure 5. Distributed strategic information systems
Figure 5, represents the idea behind this thesis, it depicts the conceptual model for designing SISs. The model shows both connectivity within the organization’s repositories and inter-organizational knowledge sharing collaboration. Org1 represents the mother organization, org1 has its own agents and it has aligned its business strategy to its information systems strategically to cater for its own competitive advantages with the “Internal knowledge elicitation mechanism”. Org1 stores its knowledge assets in the internal repositories “knowledge exploration & exploitation mechanism” and it has developed a software application for knowledge management and an adaptive network system, both managed by the software application, developed in conformity to complexity science concepts. The bold arrows inter-connecting Org1 internal repositories indicate the internal knowledge exploration and exploitation processes, facilitated by the internal SISs software application, and the adaptive network. Org2 represents all other organizations connected to Org1 for knowledge sharing purposes, the inter-organizational knowledge sharing alliance “the environment”. There is a shared repository “inter-organization knowledge sharing zone” where organizations can release knowledge perceived to be helpful for the alliance benefits, this zone was designed bearing in mind that some organizations may not be willing to share all their knowledge assets. Basically the organizations should agree beforehand how to implement the knowledge sharing process. Otherwise this thesis has recommended open data concept to solve the challenges of knowledge sharing and data privacy issues. Org1 implements its own software application designed with complexity science concepts, this software explores for external knowledge through the network. In an open data scenario, the software explores knowledge from open repositories in other organizations. In the case of shared knowledge zone the software exploits the available knowledge assets. The software application is programmed to search for the necessary knowledge in tandem to organization’s challenges.

In the beginning, organization’s ISs experts should program the SISs software application, connecting key business processes to corresponding knowledge repositories, this should be a one-time processes. The software application contains key algorithms that facilitate process listening, learning, creating and saving patterns, validating processes from specified business processes, acknowledging the processes and informing the necessary persons or devices, knowledge elicitation, prevent duplication of information and knowledge management. Therefore, the SISs application should aid the organization in determining when to change the business strategies, for the knowledge from other organizations should inform of shifting competitive landscape. The application is to be developed in conformity to concepts of complexity science, it should facilitate knowledge adaptation to business processes, the application should learn over a period of time what kind of knowledge the organization deals with. It is from such learning that the software application should explore knowledge from external repositories, if it does not exist internally. The application should be programmed so that it learns from the environmental trends, previous trends stored as patterns, should aid to predict the future. Once the new knowledge is delivered it should be validated, stored and used. The design incorporates external network as a SISs, basically the network represents the whole system, made of individual agents. Therefore, the network should conform to the concepts of complexity science as well. The network should transition and transform automatically as new agents join and existing ones leave, this thesis has used generative network automata to demonstrate the automatic process.

The design advocates for a rigorous knowledge management within the home organization first “Org1”, development of a SISs that assists in eliciting, managing and delivering knowledge to the key personnel or devices automatically, the organization
should strategically align its business to ISs systems first. The SISs should learn and evolve in tandem with the organization’s knowledge assets, it should be able to monitor user processes, refer to its memory vault for process validation and counter check operations and processes (guard operations). The model advocates for an intelligent way of designing SISs for organizational competitive advantages, a model that dares information systems researchers to think outside the box, towards the future of computation. There has been many successful designs for SISs, both as software and hardware. However, this study has not encountered an automated SISs, one that adapts, learns through its own processes and evolves. The idea presented by this thesis is to design such a system, thesis question poses “how” to design SISs in complexity science concepts? Self-organizing, self-aligning.

Although such SISs may seem unattainable from an abstract level, the author of this thesis refers to Google’s search optimization as a sample of an automated complex strategic information system (Desai, 2011). The search optimization is able to learn the user’s favourite topics from the search history, the application is capable of suggesting sites and offer targeted advertisements for it has a location tracer. The application is able to learn and adapt to user’s choice (Desai, 2011). To understand the SISs design, it is important for the organization to understand what the system will do and what will be the impact to the organization. The first phase should involve determining key knowledge assets, this thesis proposes use of Knowledge Assets Value Dynamics Map (KAVDM) in for the process, for determining the value of knowledge assets. Secondly, the organization should explore the interaction plan between its systems and those of strategic partners. The design and the alignment should be considered after these preliminary processes.

This thesis proposes methodologies for implementing the SISs design. Systems thinking originates from the biological sciences, even though it has a wide application in many sciences. Systems thinking allows easy understanding of “reality systems” that focus on the relationship between the agents, rather than the agents themselves (Schiuma, Carlucci, & Sole, 2012). A system is a combination of elements, where each element’s behaviour influences the other element while contributing to the overall behaviour of the entire system, just as witnessed in complex science (Rapoport, 1986). Systems thinking are based on assumption that the systems analysis accounts to all agent’s individual analysis. Systems thinking comprises of several methodologies and tools, whose purpose is to disclose the system’s relationships. Among others we have; Soft Systems Methodology (Checkland, 1981), the Spiral Dynamics Theory (Beck & Cowan, 1996), the Life Cycle Assessment by Miettinen and Hämäläinen (1997), the System Dynamics, (Morecroft & Sterman, 1994), among others. These techniques advocate use of non-linear models dynamic interconnected elements. Therefore, system thinking framework describes the behavioural characteristics of a system by using causal loops diagrams, depicting the operational structures. They are built of arrows denoting links that connect agents, for example entities that evolve over time. The diagrams represent agent interaction, showing how elements affect each other. Therefore the framework enables analysis of the dynamic behaviour of the thinking system. An important feature for assessing the knowledge assets dynamics and their impact to an organization (Schiuma, Carlucci, & Sole, 2012).

Thinking systems are complex systems by their own right, they are also used strategically for organizational competitiveness. Thinking systems can be embodied in software applications or hardware, engineered as strategic information systems, they can drive analysis of knowledge assets inside and outside the organization, management of thinking systems can impact on organizational value creation capacity. It supports the
dynamic mechanisms (systems alignment) connecting knowledge assets (repositories) and their management to achieve business performance improvements (Schiuma, Carlucci, & Sole, 2012.). To implement the proposed conceptual model, business strategy managers have to craft a conducive working environment with strategic information systems designers, for processes interpretation and systems improvement deliberations. It may be hard for a business strategist to understand why s(he) needs information systems to implement his strategy and that is a viewpoint shared by many business personnel (Buhl et al., 2012). For business personnel, the executive understand the importance of investing in innovative knowledge assets management methods through strategic information systems, it might be prudent to start from the basics.

This thesis proposes use of the Knowledge Assets Value Dynamics Map (KAVDM), as a basic visual tool for analyzing the value of converting knowledge assets into value, because it is imperative to convince the executive and other normal business oriented personnel why they should invest in advanced strategic information systems. KAVDM can be considered as a basic tool in the initial stages of the implementation process (Tsoukas, 1996), it can also be used by the strategists for linking knowledge assets to performance objectives and establishing priorities (Schiuma, Carlucci, & Sole, 2012).

KAVDM contains three building blocks, in the identification of key dimension of the information system process;

- The organizations business performance
- The key knowledge assets
- The management initiatives for developing define knowledge assets value drivers.

Therefore, there has to be a clear road map on the organizational business performance targets, identification and definition of the knowledge assets value drivers and the management techniques of the identified knowledge assets, while developing the SIS applications/hardware. The second phase of KAVDM (representing the SISs in this context), involves analyzing the relationship (strands) governing the connection of the knowledge assets value drivers, knowledge assets management initiatives and business performance (Schiuma, Carlucci, & Sole, 2012).

CIMBA was designed to enable internal knowledge management first, as the tentative model advocates. However, the need to incorporate clients’ systems with CIMBA led to extension features to accommodate customer orders, feedbacks and communications mechanisms. CIMBA also connected geographically distributed Infosys branches. In the tentative conceptual model for distributed SISs design, organization connectivity has been represented by Infosys branch offices. CIMBA model conformed to complexity science concepts to some extent, even though the new system could not yet learn the business processes for future prediction, as Infosys expected.
6. Findings and Discussion

This chapter presents the findings derived from this study. While focusing on the concepts of complexity science on strategic information systems research, this thesis advances its observation. The idea of deriving design model from complexity science concepts came from the Merali et al., (2012) paper Information systems strategy: Past, present, future. Merali et al., (2012) researched on innovative ways of utilizing complexity science in SISs research. However, this thesis deviated from their main topic of advancing the research to advancing the SISs design using the same concepts. Merali et al., (2012) and this thesis agree that the future challenges of SISs will continue to deal with complexity dynamic, networked, technical, social, political and economic contexts. While Merali et al., (2012) called for researchers’ collaboration, this thesis went on to propose close collaboration between business strategist and ISs experts, so as to bridge the gap between the two study fields and enable implementation of SISs research in the industry. Merali et al., (2012) focused on SISs research and advancement using complexity science. This thesis proposes SISs design advancement using complexity science concept, design science research and action research combination in the study of both ISs and complexity science concepts, so as to understand and learn the interaction patterns, for advanced software applications and systems design and development for competitive advantages.

Kauffman’s (1993) work on biological evolutionary systems demonstrated abilities for complexity science to provide concepts for invention. He examined the roles played by complex adaptive systems in the interaction of size and independence, conceptualizing evolution as the process of search over a fitness landscape. Kauffman contributed to the understanding of evolution by linking the adaptive process to the organismic genetic structures. It is from the interdependence of the genetic structure that the topology of the landscape was generated, which determines the status of the search mechanism. Also his model presented the interdependence of genes as individual agents that contributed to the adaptability of the organism as a whole. From Kauffman’s model this thesis deduced the SISs as a recombination of new and old agents of technologies, drawing from his model to develop a knowledge search process as an invention. Knowledge exploration was factored in the conceptual model, at agent level greater inter-dependency increased the probability of knowledge search and management success. However, as the degree of interdependence increased, the degree of synergetic combination to form the whole system was fading, hard to figure-out. Kauffman also observed as the number of agents grew the usefulness of the combination grew. In his final results he observed that the networked evolution process was characterized by intervals of punctuated equilibrium of rapid changes, exhibited in this thesis by graphical representation of generative network automata. Scholars who are well versed with evolutionary analogies suggest that technological inventions rise from recombination and synthesis of different technologies (Hargadon & Sutton, 1997).

Complexity science systems are fluidly changing, integrated and distributed components that react directly to one another and to the environment in which they belong (Eoyang, 2004). The proposed conceptual model in this thesis did not only emphasize internal SISs management but also creation of inter-organizational alliances for knowledge sharing. These alliances would enable environmental factors to be captured through the systems, aiding the organization to maneuver through the economical turbulences.
Henderson, Venkatraman, Luftman, Papp and Brier’s frameworks for strategic design for ISs did not capture the need to factor environment (Pijpers et al., 2008), a vital element in today’s unpredictable economies (Merali et al., 2012). Pijpers et al., (2008) also proposed a business-IS alignment framework for competitive purposes, they factored the inter-organizational alliance relationships. They also proposed inter-organizational alignment, basically what they proposed was organizations to create strategies together and implement them in unison. That process would require a lot of inter-organizational cooperation, resources and time. Secondly, with business strategies shifting now and then how would the inter-organization alliance manage the alignment? Our tentative conceptual model proposed an inter-organizational knowledge sharing repository zone, eliminating the need for over-reliance on each other, spending of excessive resource and expert time. Secondly, our model proposed an automated alignment, a process where the system learns the environmental trends from other organization, analyzes it against the internal knowledge to automatically determine business strategy shift priority, the process involves sending confirmation messages to the concerned person, responsible for monitoring the processes. There is a great need to automate alignment, it is impractical to keep on programming orders into a system with today’s technologies.

The complex distributed ISs is a prominent topic in the ISs research fields, as a ubiquitous information technology (IT) enabled product, services and expertise expansion. The research of SIS may expand to encompass the whole management field, ISs have the capability to transform the strategic management field, especially due to the newer web 2.0 capabilities, social media and cloud computing (Merali et al., 2012). Complexity science concepts and modelling approaches offer opportunities to enable analysis of IT-enabled business networks, which have a profound impact on local and global economies as witnessed in the recent financial crisis (Merali et al., 2012). This thesis has used complexity science concepts largely for descriptive purposes, however, these concepts offer exploitable resources that can aid ISs to move to a more analytical level, the transition has been visible through the ISs journals and papers publications issued by organisational science communities (Merali et al., 2012). The emerging digitally networked socio-economy is highly dependent on information technology. To deal with turbulence, uncertainty and dynamism of the emerging economic challenges, this thesis calls for paradigm change into more informed, reliable and ready IT-enabled strategies. Future challenges will be posed by the complexity of technological dynamism, interaction, social, technical, political and economic contexts. This thesis expect networking thinking to be the next front for SIS research. Complexity science concepts hold promise for ISs research, the intricate relationship between IT/ISs and business provides a chance for development of the ISs field (Merali et al., 2012).

This section discusses this study in the light of strategic information systems (ISs) designed in complexity science concepts, by examining the theoretical and managerial implications of the findings. Methodological and empirical considerations are also discussed in line with the main topic of ISs design. The implications offer an interesting perspective of looking at the design, this section tries to provoke an interest to the concepts from the ISs field. Organizations are facing a major challenge in how to sustain their competitive advantage. Implementing SIS can be a complex undertaking especially without a concrete plan (Hemmatfar et al., 2010). SISs are supposed to assist organizations in establishing profitable and sustainable grounds against the forces of competition. Strategic advantages should be designed to withstand the test of time, to enable the organizations that own them to enjoy a sustainable competitive advantages for several years before competitors can be able to learn and imitate their systems models (Turban, Rainer & Potter, 2005). Basically SISs should help firms quicken their
reaction against environmental changes, key features of SISs are; decision support system that strategically aligns business strategy to ISs systems, a system that assists in enterprise resource planning, a database system that enables data mining techniques to make use of available information for business processes, and a real-time system for maintaining a rapid response mechanism (Turban et al., 2005).

The tentative conceptual model proposes a strategic integration and distribution of the SISs, an architectural structure that can have a theoretical implication for the business world. The model suggests development of an innovative SISs software application that combines independent agents to form a SISs for competitive advantage. The organization’s SISs also combines with other organizations through strategic alliances agreements to form a bigger system that searches knowledge from far and wide.

The model does not only advocate for development of outwardly focused SISs, but inwardly too. The model seeks to increase employees’ productivity, streamlining business processes and assisting in decision making. It advocates for prudent knowledge management, in that organizations can entice users to offer their own contact information through web 2.0 and social media applications. The organization can use this information for advertisement purposes, hence reduce marketing costs. The user information can be used for quality survey purposes, can be used for public relations purposes to bring clients closer to the organization. The information can be used for rewarding loyal clients too. With a more interactive SISs, clients are able to give fast feedback, complains and orders easily and conveniently through mobile devices. The organization is able to learn from its surroundings, the environment. Organizations are able to plan for the future to avoid unexpected pitfalls, they can also make maximum use of their own stored knowledge.

At this point it is agreeable that new computer architecture can be realized by exploiting the concepts of a Complexity science (Kovacs and Ueno, 2004). The knowledge gained by studying and analyzing complex systems in their natural settings has led to development of computational algorithms, networks and applications. Researchers have also reported about applications that borrow heavily from complexity theory, in that they combine mathematical schemes and programing semantics and algorithms for pattern matching through stacks of databases. The results mark a defining moment in construction of evolutionary and strategic information systems (Kovacs and Ueno, 2004; Merali et al., 2012).

The case of CIMBA conforms to Complex Adaptive Systems (CAS), but not to CES, because the new system was not able to learn from its processes yet, the designers intended CIMBA to predict the future for business planning. Mobile phone infrastructure systems are fast emerging as complex system, conforming to complexity concepts of adaptation and evolutionary transformation and transition in their rapid changing environment. Millions of mobile users visit these systems with different information needs. The servers respond to diverse requests from the users mobile consoles, these servers need to sieve precise information from a load of available information in their repositories. However, in future it is expected that the repositories for mobile information systems will be able to evolve their information content in tandem with consumer demand. Social media is emerging as tool for eliciting user generated process requirement, these instruments are vital for learning user’s behavior patterns for customer satisfaction purposes (Kovacs and Ueno, 2004.). Web 2.0 technologies have transformed SISs capabilities in harnessing user-generated content, SISs are no longer limited to supporting business processes, but also in supporting
process requirements and influencing user behavioral change and in dynamic contexts (Jiang, Mookerjee and Sarkar, 2005; Merali and Bennett, 2011).

This thesis wishes to reiterate that knowledge management is just one form of business strategy. Information systems have been portrayed as catalysts for knowledge management implementation in this study. The study asserts that organizations may become more competitive depending on how they innovate to maximally manage their knowledge inside and outside their repositories (Merali et al., 2012). Strategic information systems infrastructure, designed to enable the firm to achieve aligned knowledge management for competitive advantages, are hereafter referred to as strategic information systems.

Choosing the right SISs topics and solving business problems through ISs supported competitive advantage is not an easy task (Buhl et al., 2012). To determine the right topics researchers have to focus on advancing SISs theories, industrial collaboration for data collection purposes and the organizations should strive to create a conducive atmosphere for ISs experts to freely interact with the executives in identifying the appropriate SISs research results for interpretation and implementation (Galliers, 1991). In order to achieve this, there is need for more boundary spanning researchers. They can help inter-organizational SISs theory by validating, generalizing and disseminating insight gained through SISs business problems, so as to advance the scientific knowledge (Aldrich & Herker, 1977; Carlile, 2002; Tushman & Scanlan, 1981). This thesis acknowledges that there may be considerable challenges for SISs researchers mediating between academia and industry (Buhl et al., 2012).

Strategic information systems alignment to business strategy has been touted as a challenging affair, thus aligning knowledge assets to competitive challenges (Merali et al., 2012). This thesis has proposed a conceptual model for designing a distributed SISs. However, it would have been interesting to provide a sample algorithm, so as to capture developers’ interest. However, that was not possible due to pseudo code and man hours beyond the scope of this study. It is imperative to provide a code indicating how to link the repositories to an automatic request order (a trigger) and also a code that allows automatic process learning, the so called “sniffing”. The study proposes SISs in form of software applications that listen to input and output processes, so as to create learning patterns stored in the memory for future process validation, a process intended as a warning mechanism for bad professional practices. The study also proposes a self-organizing, learning, adapting and evolving network, which inter-connects organizations for knowledge sharing. It would have been interesting to provide a functioning prototype, even an artificial model, or a software prototype. However, resources and time have restricted such realizations.

Markus, Majchrzak, and Gasser, (2002) points on the challenges of designing for emergent knowledge processing in complex contexts, where knowledge exploration spans large networks and evolves dynamically to adapt into the new strange environments outside the mother organization. The challenges are much greater given the rise of technology today, which demolishes organizational boundaries to include external players. The process of acquiring knowledge of the open movements and of the crowd sources poses newer complex challenges in designing SISs.
7. Conclusion

This thesis proposed a new way of designing and implementing Strategic Information Systems (SISs), for organizations that are seeking to make profit from their SISs, rather than just attain process support from their information systems as it is traditionally. When an organization is able to carry a quality survey in two or few days, analyze it and present the findings, it is an organization that saves resources. When an organization can determine consumer trends from knowledge learning process, it is able to position itself strategically to satisfy the customers. These are among other advantages achieved by an innovative SISs.

Organizations that have already developed SISs based on internal resource management, can also be able to adopt the tentative conceptual model proposed by this thesis as well. The model advocates for SISs implementation in the mother organization, which many locally based firms have already done, so the next step would involve joining an inter-organizational alliance for knowledge sharing. The implementing organization would have to decide whether to share all its repositories conforming to open data concept or to share limited assets through shared repository zone. Either way the organization would start to benefit from the competition landscape, learning from the environment. The challenges lies in design and developing SISs that conform to complexity science concepts, because these SISs should be unique, it is prudent not to copy from organizations that have already implemented such SISs successfully, for SISs are supposed to be unique. Organizations willing to transform their SISs model may have to learn the complexity science principles to understand how the patterns concept works. That may mean ISs experts taking time to join a scientific group to familiarize with this concept, or the organization may just hire SISs experts who are familiar with the concepts. The advantages of this conceptual model is that, the organization can build the new design on-top of the existing infrastructure.

In a bid to craft the tentative conceptual model, this thesis firstly discussed complexity science, splits into two CAS and CES. The former has been discussed to some extent, SISs have been constructed in their form, although not yet fully functional, as seen in Infosys case. This thesis tried to model a CES system, in its tentative model. CES are systems that can learn from their processes, the only existing difference between the two. To the best of this study’s knowledge there are very few if any SISs that can explore knowledge and analyze it and utilize it for competitive reasons, this thesis did not encounter such SISs.

By taking the CES approach, this thesis was able to propose a new design model for strategic information systems. Viewing a SISs as a CES leads to a different architectural choice, which is both innovative and new. The model also suggest a different way for organizational alliance formation for knowledge sharing. The model proposes a distributed SISs, meaning intertwined SISs from several organizations, for knowledge sharing. Organizations can no longer exist in isolation but in alliances for competitive advantages (Merali et al., 2012). It proposes an easier way for establishing a shared knowledge repository zone, where organizations can release and explore for external knowledge resources. Although this thesis was not able to exhibit an algorithm or create a physical prototype for the proposed SIS model, it has explained how it can be
achieved. These systems require high knowledge in mathematical modeling in computer networks and software coding, to achieve intelligent evolving systems. Due to the time constraints, limited resources and the nature of this thesis it was not possible to commence development work. This thesis proposes a conceptual model for SISs design, there exists many other levels of discussions, debates and research before this kind of work can be developed. The next level remains as additional research
References


