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PRINCIPLES OF ON DEMAND SYSTEMS: STUDIES IN SYSTEMS ORIENTED ARCHITECTURE

By

Sascha Vitzthum
Doctor of Philosophy

Business

Benn Konsynski, Ph.D.
Advisor

Anandhi Bharadwaj, Ph.D.
Committee Member

Ramnath Chellappa, Ph.D.
Committee Member

Accepted:

Lisa A. Tedesco, Ph.D.
Dean of the Graduate School

Date

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Sascha Vitzthum

Dipl. Kfm. (Master of Business Administration and Economics),

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An abstract of

a dissertation submitted to the Faculty of the Graduate School of Emory University in partial fulfillment of the requirements for the degree of

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Abstract

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With the proliferation of Information and Communication Technologies (ICT) and the digitalization of information, services have permeated organizations and markets. Industries, public institutions, and enterprise are transforming into entities that provide *on demand* services to requesting entities. The dissertation examines the inherent principles of *on demand* systems. The studies represented in this research effort explore the presence and absence of several of the key principles underlying the *on demand* environment in order to understand and predict innovative directions in the migration toward, and beyond, *on demand* environments and future computing paradigms. The evidence gathered from the qualitative and quantitative studies suggest that the impact of *on demand* systems is contingent upon the technological and external environment in which the system is deployed.

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Acknowledgments

Faculty, peers and friends have helped me complete this dissertation. First and foremost I have to thank my advisor Dr. Benn Konsynski. Benn has been a strong and supportive advisor to me throughout my graduate school career, but he has always given me great freedom to pursue independent work. His far reaching vision and relentless desire to predict the future has inspired me to take on and complete this tremendous task. The current and former faculty of the ISOM department have been crucial in commenting and revising my work. Dr. Anandhi Bharadwaj was crucial in structuring and restructuring my work so that it would be written in a detailed and concise manner. Dr. Ram Chellappa always asked the tough questions and helped tremendously in understanding the research process. I am thankful to Dr. Michael Prietula for introducing me to computational models. The staff at the Goizueta Business School has been extremely supportive. I am particularly grateful for the often unnoticed work of Donis Leach, Patricia Chebat and Jalisa Norton. Finally, I would like to thank my peers for their support and friendship. Without the relentless support of Dr. Beth Tarasawa, Dr. Eric Overby, Dr. David Bray and Abhishek Kathuria I would not have made it this far.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

CHAPTER I: INTRODUCTION

Since the industrial age, the provision of service has risen to the forefront of economic activity. Service provision and co-creation have become pillars of today's mature economies. With the proliferation of Information and Communication Technologies (ICT) and the digitalization of information, services have permeated organizations and markets. Industries, public institutions, and enterprise are transforming into entities that provide *on demand* services to requesting entities, which may or may not previously have had a relationship with the service provider, creating a value network that is formed based on market demands rather than on organizational design and structure. Instead of pushing services to potential consumers by means of marketing or long standing sales relationships, services are published by providers and subscribed to by consumers on an as need basis. The evolution and subsequent adaption of information technologies that provide standardized interfaces has been one of the key drivers of this macro trend.

Chapter II identifies the impact of *on demand* systems through an investigation of trends in the public domain. The initial section examines the historical development of information systems architecture from reliable, but hardwired and inflexible solutions to the service oriented architectures of today that promise positive outcomes such as flexibility, responsiveness and agility. The study concludes by providing empirical evidence that depicts the current state of Information Systems architecture.

Chapter III considers the theory of Service Orientation in the context of service systems. It examines Service Oriented Architecture principles stemming from the Computer Science and Systems Engineering disciplines and considers technology independent system attributes and principles that can be used to examine other forms of systems regardless of their nature, identifying key elements in a theory of Service Orientation.

Chapter IV changes the locus of analysis by focusing on the enterprise. The research is motivated by the notion that increasing complexity of the turbulent environment demands agile enterprise that can create and exploit digital options (Sambamurthy et al. 2003). It examines how configurations of Information Systems architecture, classified by the system characteristics stemming from Service Orientation, enable or prohibit appropriate responses to changes in the external market environment. Based on quantitative results of a computational model, the study evaluates the success of information systems architecture in aligning IT systems capabilities with constant changes in the turbulent market environments. The study concludes by assessing the viability of service oriented Information Systems configurations in the context of environmental change.

Chapter V examines communication patterns in social networks and how the evolution of Information and Communication technologies (ICT) impacts the communication process. ICT enable a more diverse portfolio of opinions and beliefs among Internet users through the *democratization of access* and the *democratization of participation*. This study examines how the diffusion of information changes with a more diverse and more dispersed user population by investigating the effects of network composition, size and structure on information diffusion in these virtual networks. It extends the Axelrod cultural model (ACM), an established theory rooted in political science research that examines information dissemination among actors with limited communication reach (Axelrod 1997). The study employs a computational model to investigate the effects of changing network structure parameters. The research affirms that the gossip based mechanism employed in the ACM lead to local convergence but global divergence of actor attributes. However, the research also provides insight into the role of convergence velocity into the extent of the convergence mechanism and the applicability of the model to future research in ICT enabled virtual networks.

Chapter VI involves a descriptive investigation of the current landscape of information driven institutions, and how deployment of on demand systems can leverage the complexities of information intensive environment. The chapter incorporates findings from three case studies to evaluate the impact of modern Information technologies. The first case study examines the impact of peer-to-peer (P2P) and Voice over Internet protocol (VOIP) technologies on the telecommunications industry. The second case study investigates the impact of Radio frequency identification technology (RFID) on the business model of a large logistics provider. The third case study goes outside the realm of the enterprise by evaluating the effects of Unmanned Systems (UMS) on the rules and principles of modern military organization and operation. The chapter concludes by summarizing the trends that can be seen across the case studies and by distilling principles of *on demand* deployment.

The conclusion summarizes the findings across the different studies. It categorizes the findings based on the characteristics of the external and technological environment, which impact on demand systems. A brief overview of the key dimensions covered throughout the dissertations is provides in Figure 1. The chapter is brought to a close by providing an outlook on the future impact of Information Systems in a *post* on demand world.

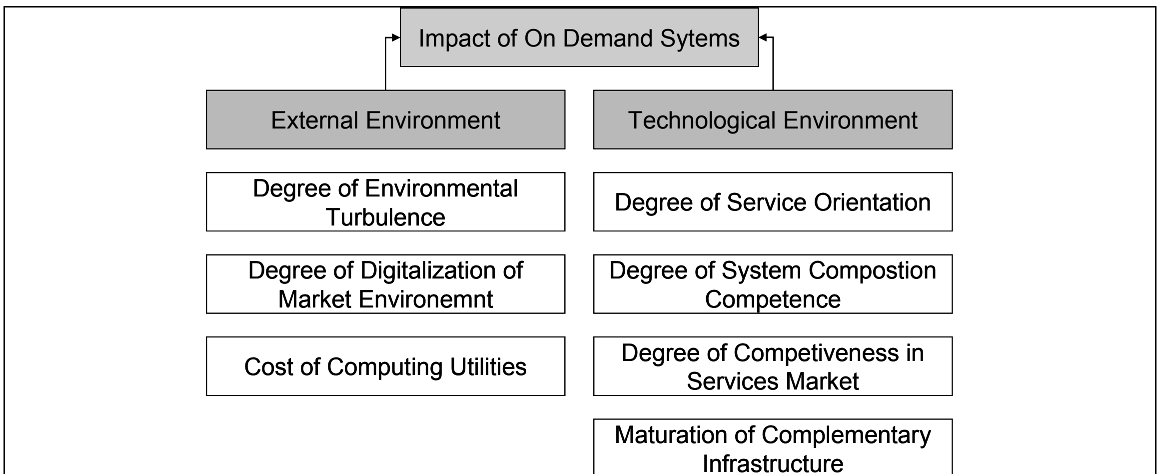

Figure 1: Impact of Environmental Dimensions on the Success of On Demand Systems

CHAPTER II: PRINCIPLES OF ON DEMAND SYSTEMS

While offering significant value through the leverage of information technologies, the contemporary enterprise is facing two imperatives, on one hand risk and growing complexity of its systems and procedures, and second the need for lowering cost and sharing resources. The cost issue is true, even in the face of extraordinary efficiencies and economies in computing resources. Costs have been addressed via migration to architectures that tolerate outsourcing, internal shared services and reliance on remotely hosted applications (e.g. software as a service).

On demand services provides a framework for evolution of both legacy and new systems that employ new computational infrastructures such as utility computing, automatic computing, web services, grid computing, cloud computing and other forms of service oriented computing infrastructure. In an on demand services environment, resources are made available and provisioned as needed. The services and resources may be maintained within the user enterprise, or may be made available via subscription of syndication of a service provider.

While few examples of pure on-demand service operations exist today, the migration and evolution of IT architectures and development practices are adjusting to the adaptive environments suggested by an on demand ecosystem. The objective is a business/market policy driven model for technology and the enterprise. It represents a continuous transformation rather than a disruptive revolution. On demand environments require principles of definition and policies, protocols that define implementation in the context of the operating environment, and standards that permit establishment of resource-sharing arrangements dynamically with all subscribing and participating parties. The current environment involves a plethora of balkanized, incompatible, non-interoperable distributed systems. The principles thus lead to standards that ultimately identify general-purpose services and tools and define operating environments.

Scale issues are addressed in these environments, supporting fluctuating demand. Resource demands vary drastically from one time to another. The emergence of sharing computation, storage and communication resources, are essential in understanding the evolution of the on demand environments that are taking shape (Smith and Konsynski 2004). From the early days of computing with stand-alone mainframe computer devices with concurrent, co-located operations, data communications capabilities changed the options for operation. Following several decades of this form of operation, operating systems and communication systems emerged that leveraged the core computing and storage capacities in shared environments. We often refer to this as time-sharing – offering computing and data resources from data centers located at different centers around the world. To accommodate this business practice, operating systems and systems operations evolved to support needed security, control and accounting activities. The centralized operations centers operated as regulated monopolies.

As mini computers emerged on the scene, the business model was challenged as servers proliferated and new back-end control mechanisms were needed. As with the advent of the personal computer, the now free market of capability called for principles of security and integrity. The free market required some regulation in order to deal with the proliferation of applications, models and data that lacked appropriate controls. Utility computing, shared services, outsourcing and software-as-a-service (SaaS) environments evolved. The grid computing, automatic computing and utility computing trends converge toward cloud computing, the ultimate of utility models. Virtualization in operating system environments is now commonplace. A pathway to proceed to adoption of on demand principles is open.

Virtual pools of resources and cloud utility infrastructure will be a failure unless there are principles, protocols and standards that deal with intra-organizational and inter-organizational provision of services and multi-vendor cooperation. The principles that exist in the development and provision of open source resources are a consideration in the acceleration or delay in adoption of on demand principles. Scale economics are not yet clear, and will likely be a key factor in the early stages, except where high demand volatility reveals high value in radical scale adjustment. The organizational, management, business and market practice challenges remain. It is the intent of this research to explore a number of the key principles of the evolving on demand environments from several perspectives.

This chapter identifies a number of the key principles of on demand business. It first traces the evolution of information systems and identifies underlying technological trends that have led to the current distributed information systems. The next section identifies requirements for future on demand systems. It concludes by identifying the principles of business oriented on demand systems and by identifying the need for a new IT architecture approach.

Information Systems Evolution

Since the introduction of modern IT over 40 years ago, information systems have evolved from support systems that were used for highly specialized task, to a complementary resource that is vital for the majority of businesses (Bharadwaj 2000; Melville et al. 2004). This section provides a brief overview of the evolution of information systems, and their core capabilities and their predominant functional use in organizations.

In the 1970's mainframe computers were the main information technology used in business. Mainframes are characterized as stand alone systems that centralized both data computing and data storage (Barrett and Konsynski 1982; Carr 1987). The systems were set to compute a single process at a time and the priority of processes were determined by the system administrators. The systems were hardware driven and only had few software programs that were used for basic data processing. The system capabilities were mainly used to automate existing processes in few business functions such as payroll, billing and inventory management. The mainframes were usually not interconnected with other systems, since standards for manual and electronic communications were proprietary in nature. Users relied on terminals, which could not process data, to input data that would then be relayed to the server for data processing. In summary, the first generation of information systems had centralized processing and data storage, was not connected to other systems, and was based on proprietary standards and protocols.

The 1980's were characterized by the increasing affordability and use of personal computer and the proliferation local area networks (LANs). The new computing capabilities enabled users to locally compute and process information and to digitally exchange information within the corporate network. While the mainframes still had their part in basic processing, the interconnected IT infrastructure became more distributed and more accessible to individuals. Processing was still centralized but gradually became distributed. It started to take place in the individual computers and was eventually shared or distributed between the computers in the LAN. The connection of different systems can be considered as the first instance of distributed IT architecture, since processing was spread out across different systems. Thus, the second generation of information systems can be characterized as having centralized storage, while processing was distributed between centralized servers and networked computers. The increasing connectivity in the era was spurred by the emergence of communication standards. The standards were developed by industry consortiums (e.g. The SWIFT protocol for financial transactions) and hardware vendors (IBM's System Network Architecture) (Karimi and Konsynski 1991).

The early 1990's saw the rise of Wide Area Networks, exemplified in the deployment of electronic data interchange (EDI). Based on standardized data transport and system communication protocols, intra-enterprise data exchange started to take hold. Processing could now take place outside side of the organizational boundaries, carried out by a strategic partner or third party (Konsynski 1993). At the same time internal systems became more integrated, the formerly dedicated systems were connected providing an enterprise wide information system. The predominant model was the client server systems which takes advantage of the processing capabilities of the host machines and the personal computers. The workload was split based on the configuration of the systems. It ranged from truly distributed system where all the data, application and software would be hosted at the server, to setups where only data was stored at the server and all applications and software processing took place the client side. The client server model was successful for integrated entities but proprietary operating systems and legacy software proved to be a high burden for connecting to a globally distributed information system.

In the mid 1990's the Internet replaced dedicated linkages as the main platform for data interchange. Based on open standards and communication protocols (e.g. TCP/IP), systems could interact globally without the need for an accompanying proprietary infrastructure. The client server model remained intact but was now working on a global scale. Client computers connected to the Internet now had and the ability to draw from the resources of equally connected servers. Processing could now be shared and scaled based on the immediate needs of an entity. In addition, geographically dispersed databases could now be accessed eliminating the need for local storage. Thus, information systems have evolved into complex network of systems that has the capability to process and store nearly infinite amount of data. Yet despite the possibilities of the Internet enabled system of systems, there are still technological and governance hurdles that need to be overcome to fully leverage those described capabilities. The main findings form this review are depicted in Figure 2.

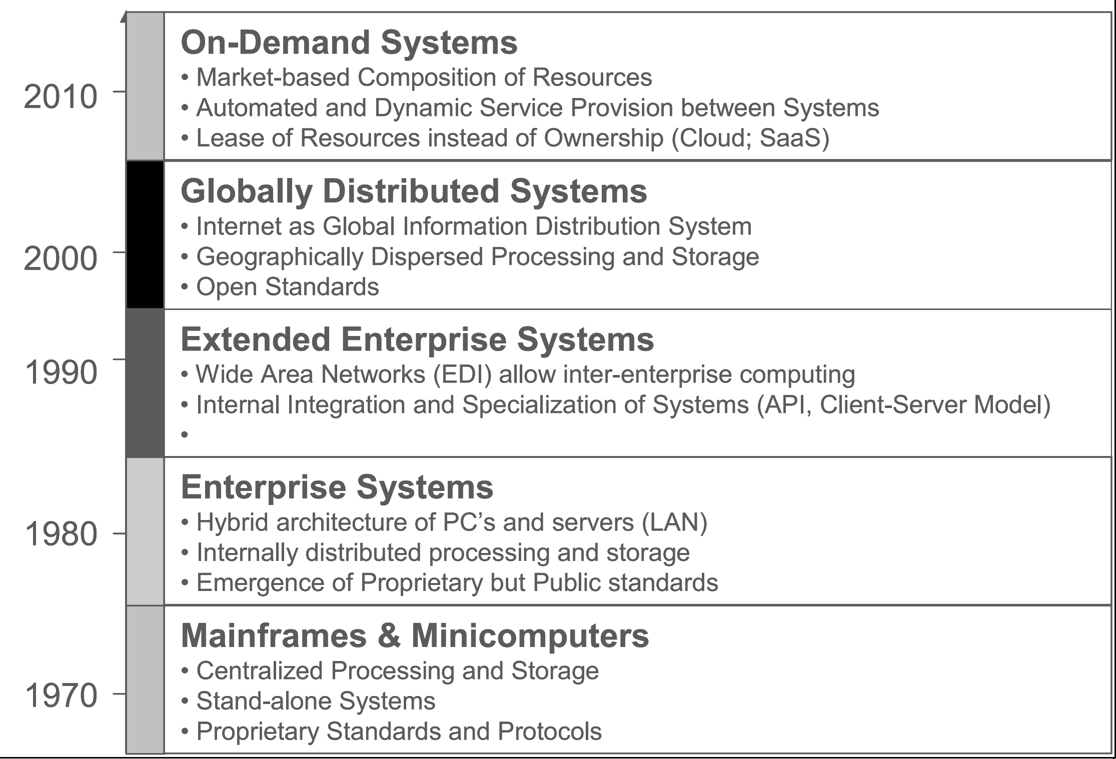

Figure 2: Evolution of Information Systems

Environmental Shifts

The evolution of information systems in the enterprise followed several trends in regards to distribution, connectivity and interoperability. This section briefly reviews those trends and evaluates their impact on *on demand systems*.

Protocols and Standards Change from Proprietary to Open

The communication standards and system interfaces have moved from proprietary nature to open forms backed by the majority of vendors. The initial idea behind the openness of standards was to avoid being locked into the proprietary standards (e.g. IBM's SNA) of a single vendor. In the 1980's openness of protocols was formalized in the Opens Systems Interconnection (OSI) reference model. The OSI describes a layered architecture, where the each layer represents a different service that needs to be performed. Within each layer data gets encapsulated and control information is added so the next layer can interpret the transmitted information. Protocols ensure that this "translation" occurs properly. At each layer passed information can be interpreted because the control information is a standardized interface that the respective layer can interact with. The OSI model was first applied to telecommunications in the 1980's allowing new innovative applications (i.e. Caller ID) to be integrated into the overall system. The Internet is based on the 7 layer OSI model, allowing systems and applications to connect to globally dispersed networks.

The early 1990's saw a shifting focus of openness to the interfaces between applications. Open standardized interfaces allowed for interoperability between networks, operating systems and databases. The development of application programming interfaces (API's) became the key concept of that era. Similar to the role of protocols in the OSI model, API's define the way that components are presented to other components. API's define the input and output presentation of an application. Applications can interact if the communication adheres to the standards presented in the API, regardless of the functionality that is encapsulated in the application. APIs aided in the increased interaction between systems, but they were still idiosyncratic to individual applications. If a new system is to interact with different applications, the output still needed to be tailored to each corresponding API.

From Centralized to Distributed Systems

Interoperability between systems has increased with the proliferation of open communication protocols and standards. The original mainframes were dedicated systems that ran specific business functions and applications that were concerned with data processing and data storage. Today's information systems are distributed and can be accessed from any connected device, assuming that access privileges are granted.

Distribution will further occur as systems will interact with systems without the supervision of human operators. Machine to machine, or system to system interaction will be a key challenge for information systems research in the future. Issues related to this new form of interaction are examined in the following chapters.

From Scarcity to Abundance

In the early days of information systems, both processing and storage were scarce. The first hard drive sold commercially by IBM in 1956 sold for USD 50.000. It had a storage capacity of 5 MB. In the early 1980's, prices decreased to under 200 USD per megabyte. Currently prices per megabyte of storage are less than USD .001 per megabyte. The cost for storage have decreased exponentially (Bower and Christensen 1995).The same decrease in cost is true for processing power. The cost of processing halve approximately every 24 months (Tam 1996). Both storage capacity and processing power follow Moore's law which states that that the capacities are growing exponentially. Available bandwidth is the third technological resource that has followed this trend. Between 1979 and 1997 bandwidth has doubled eight times. The technical developments have created an environment were IT resources have become "too cheap to meter" (Anderson 2008) and have been considered a commodity (Carr 2003).

Information systems have undergone tremendous changes in the last four decades. Initially envisioned as expensive stand alone calculating machines, information systems have become a global system of systems. The underlying IT technologies have become a commodity that allows for distributed storage and processing leading to nearly infinite scalability of resources. Future revolutions in information systems will stem not from the ownership of IT hardware, but in the efficient leverage of applications, and market-like competition between applications in the business environment. Similar to the developments in the IT hardware arena, applications will become more distributed. The decentralization, distribution and reassembling of IT related resources has reached the layer of applications. Applications will disintegrate into components that will be constantly rearranged based on the demands of networked organizations. Systems will be fluid and constantly change: they will become *on demand systems*.

Evolving On Demand System Principles

Each new generation of Information systems was fueled by new technological innovations and saw an increase in productivity and spending. It can be inferred from the exponential increase in the core IT hardware capabilities (processing performance, storage and bandwidth) that information systems have matured. Businesses should no longer be challenged with maintaining and networking information systems. The abundance and ubiquity of the underlying technologies shifts the enterprise focus on enabling and assembling agile information systems that can respond instantaneously to the changes in the turbulent and information intense environment.

Componentization and Remixing of Applications

We may expect that the next innovation in information systems will take place at the application layer. Applications will need to be disassembled into components that deliver specific service and then reassembled, customized to the market needs. This is evident in the evolving forms of web services, software-as-a-service and models of cloud computing architecture.

As we have seen in the previous discussion, this modularization can involve a sizeable amount of recoding. In addition, if the application is proprietary, only the initial application provider has the source code to do so. In many cases the deconstruction might not be feasible, because the internal interfaces and data transfer protocols are idiosyncratic to the legacy application (Marwaha and Willmott 2006). Extracting the business logic and rewriting the component in a standardized manner will frequently be the better solution. The components will have to be encapsulated and have to function independently of other components. Ideally, they only have to rely on a standardized input to perform their designated service.

Once components are properly designed they can interact with other components to form a portfolio of services that is customized to the needs of organizations. The reassembly will not be a static process. Components will be added or dropped based on the current needs of the organization, because they are loosely coupled instead of preprogrammed or hardwired. Moreover, the performance of services will be continuously measured and evaluated against the performance of external components that are available from external providers and exchanges will take place if new components perform better services. Thus, distributed applications will continuously change.

From Owning to Renting

A model of continuous adaptation to the demands of the environments makes ownership of individual components unnecessary. Ownership of components would inhibit the constant exchange and adaptation of the information system. Again parallels to the previously described development of hardware based information systems can be drawn. Investing in a new server not only creates cost of acquisition and ownership, but it also locks in the acquiring company into a technology that will perform half as effective as the next generation. Based on Moore's law, processing and storage capabilities of the server will be antiquated only 18 months after the purchase (Demirhan et al. 2006). Thus, companies have moved to renting storage form specialty providers like Amazon S3 instead of owning their own storage technology. The provider can incur scale benefits benefit from its specialization which will be partially passed along the subscriber. The same would be true for application components. Rather than relying on a single application that is owned (internally developed or purchased from a vendor) and being locked into the functionality provided until an update is available, companies should rent components from multiple entities that compete for providing superior services.

From Closed Applications to Service Markets

In order for organizations to source services on demand, a market for the services has to exist. In theory, services should be readily available in distributed information systems. However, markets for services distributed on the Internet are still in their infancy (Cheng et al. 2007). While the markets do not emerges in the theorized forms, there could be cloud based models that spur the exchange and use of services.

The basic functionality of web service has described by (Hagel and Brown 2001). A typical web service needs to be described by the service provider, published in a common directory and then subscribed to by a requestor. Underlying those processes are three communication protocols and three software standards (Hagel and Brown 2001). XML (eXtendend Markup Language) describes the data in a standardized way that different application can use the data. XML is wrapped around bundle of services and their functionality. The publication of the web service description is performed by using the Web Service Definition Language (WDSL). It standardizes the information enabling service requestor to interpret the functionality of the services. The service description is located in the Universal Discovery, Description, and Integration (UDDI) which acts as universally accessible directory. Once a service has been requested the requestor and the web service communicate via the Simple Object Access Protocol (SOAP). SOAP enables loose coupling by binding the requestor and service and immediately invoking it, with out the need of a preprogrammed or hardwired. As with the transmission of the Internet, HTTP (Hypertext Transfer Protocol) indicates the location of the web service while TCP/IP (Transmission Control Process/Internet Protocol) warrant that the communication can take place across networks. The transaction model of services id depicted in .

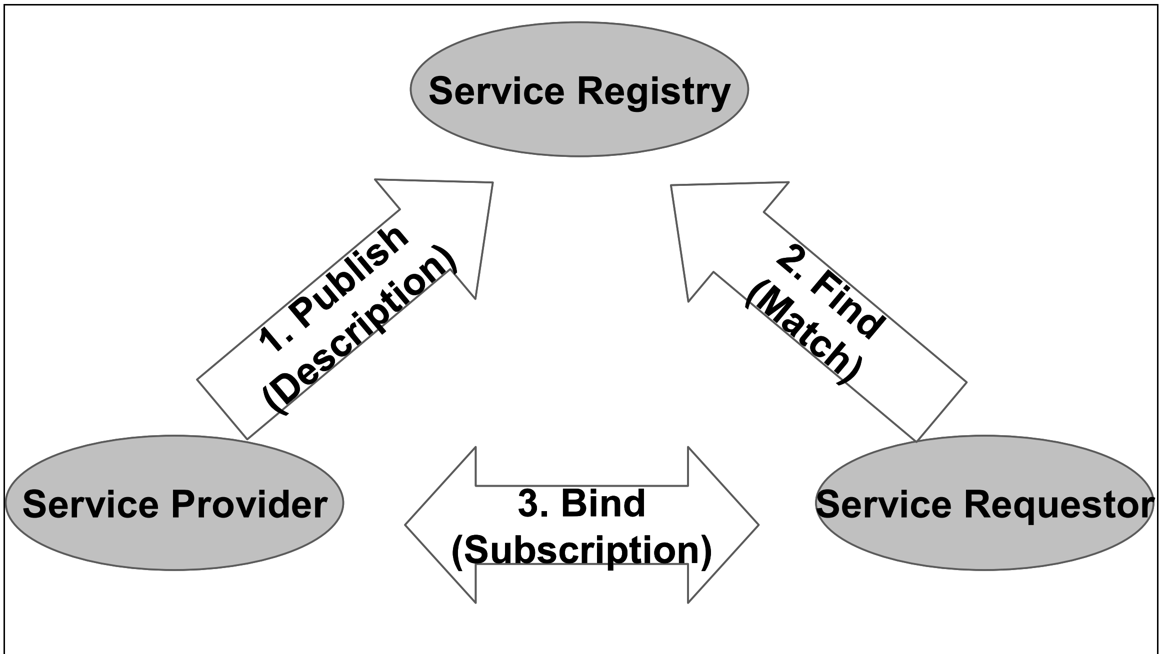

Figure 3: Transaction Model of Services

Web services are designed for system to system communication. They are loosely coupled by design, expecting to perform a service only for as long as it needed (Hagel 2002). The service contract is spelled out and includes not only the description of the service itself but also the terms and conditions, which contain the usage fee agreements under which the service is performed. Web service have been dubbed the first instance of the transactional web (Gottschalk et al. 2002), since all the aspects of the truncation process are described *and* fulfilled. Hence, distributed applications based on the web service concept will be the result of automated transactions and performance based composition. The services will incur usage based fees rather than the predominately fixed cost of current applications (Dos Santos 2003).

Summary

The initial evolution of information systems is characterized by technological advances initially spurred by innovations in IT hardware that improved processing and storage. Innovations in design and operation were driven by quests for resource allocation efficiencies while attending to integrity, risk and security issues of the enterprise. Spurred by the development of open protocols and standards, centralized systems gave way to distributed systems that extended their reach from inside the organization to a global scale.

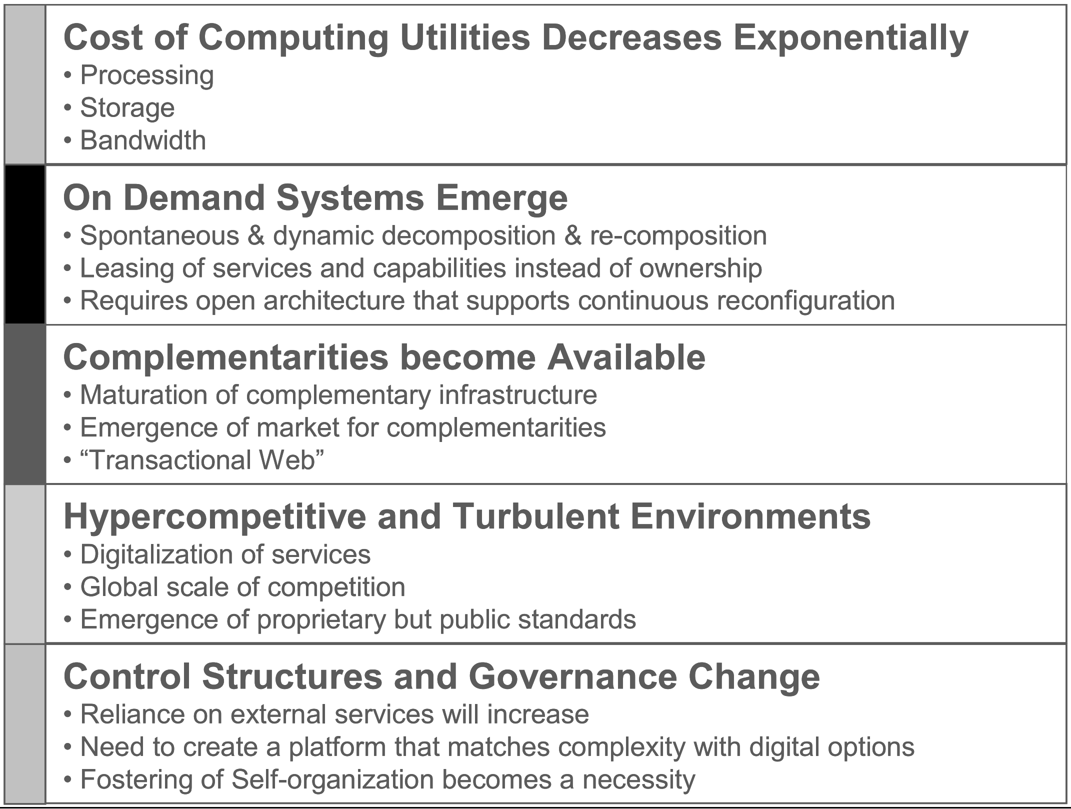

Figure 4: Summary of Trends and Evolving Principles

The maturity of networked systems has created opportunities to decentralize applications and to create agile information systems can not only be dynamically configured, but will show tendencies towards self organization. Web services have emerged as the key concept toward attaining a transactional web which allows for competition based on application composition. In order for the transactional web to take place, IT architectures have to be reconfigured from proprietary systems to open architectures that allow for the proper design and implementation of web services. The next chapter reviews the design principles of Service Orientation which will serve as the architecture paradigm for on demand systems.

CHAPTER III: ON DEMAND ARCHITECTURES AND SERVICE ORIENTATION

Service oriented computing (SOC) is the computing paradigm that utilizes services as fundamental elements for developing applications (Papazoglou and Georgakopoulos 2003). SOC involves the service layers, functionality, and roles as described by the extended Service oriented architecture (SOA). As an emerging computing platform, SOC encompasses a design paradigm (Service Orientation), an architectural model (SOA), and solution logic. The most basic unit of service oriented solution logic is a Service. Services have distinct design characteristics that support the goals associated with SOC.

SOC aims to enhance flexibility, agility and productivity of software by positioning services as the primary means through which the realization of strategic goals is accomplished (Erl 2005; Erl 2008). SOC accomplishes those goals, by allowing for rapid, low-cost and uncomplicated composition of distributed applications in heterogeneous contexts and environments (Papazoglou et al. 2006).

This chapter identifies the main components, relationships and principles associated with SOC. The first section identifies the primary elements of the SOC platform: service oriented architecture, service orientation. Service oriented solution logic and services and surveys their basic relationships. The second part investigates the design principles inherent to SO and examines the potential tradeoffs that can occur between the design principles. The chapter concludes by investigating the overarching philosophies that are underlying SO.

Components of Service oriented Computing

Service Oriented Architecture (SOA)

Service oriented Architecture refers to the platform architecture or environment that underlies the service design and creation. SOA is typified by technologies and platforms that allow for the creation, execution and evolution of service oriented solutions. The technology platform that is based upon the SOA model creates an environment that is suitable for solution logic that has been built in compliance with service orientation design principles.

Service Orientation (SO)

Service orientation is a design paradigm compromised of a specific set of design principles. A design paradigm within the context of business automation is generally considered a governing approach to designing solution logic. It normally consists of the set of complementary rules or principles that collectively define the overarching approach represented by the paradigm.

Services

Any person caring out distinct tasks in support of others is providing a service. Any group of individuals collectively performing a task in support of a larger task is also demonstrating the delivery of a service. Similarly, an organization that carries out tasks associated with its purpose or business is also providing a service.

A task that is well defined and does not overlap with associated tasks can be described as a service. In order for service providers to collaborate, collectively providing a larger service, the services need to have fundamental common characteristics. Establishing these types of baseline design requirements is a key goal of SO.

A service can provide a collection of capabilities. The capabilities are grouped together because they relate to the functional context established by the service. A service essentially acts as a container of the related capabilities. It is compromised of the body of logic designed to carry out these capabilities in a service contract that expresses which of the capabilities are made available for public invocation.

SOA and SO are the main factors for creating and executing Services. SOA creates the platform or environment for the creation and execution of Services, while SO governs the design principles of both the environment (SOA) and the Services.

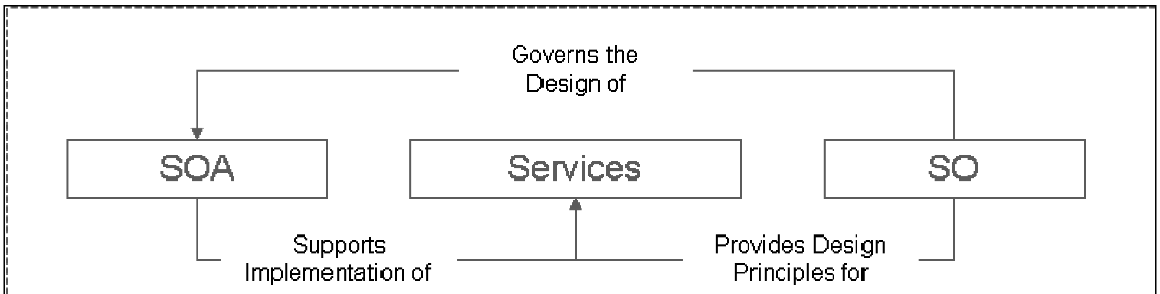

Figure 5: Basic Relationship between Services, Service oriented Architecture, and Service Orientation

Solution Logic

The solution logic is defined as the application of design requirements and principles to the creation and composition of services. When solution logic is consistently built into services and when services are consistently designed with these common characteristics, SO is successfully realized throughout an environment. In essence, the solution logic enables the seamless composition and choreography of services according to the goals of an operation.

When building distributed solution logic, design approaches revolve around a software engineering theory known as the separation of concerns (Ossher and Tarr 2001; Parnas 1972). This theory states that a larger problem is more effectively solved when decomposed into a set of small problems or concerns. This provides the option of partitioning solution logic into capabilities, each designed to solve an individual concern. Related capabilities can be grouped into units of solution logic. Different design paradigms exist for distributed solution logic. What distinguishes SO is the manner in which it carries out the separation of concerns and how it would change the individual units of solution logic. Applying SO to a meaningful extent results in solution logic that can be safely classified as "service oriented" and units that can qualify as services. To understand exactly what it means requires an appreciation of the strategic goals of service oriented computing combined with knowledge of the following service oriented design principles.

Service Orientation Design Principles

The computer science literature has derived seven distinct service design principles (Erl 2008): Standardized service contract, service loose coupling, service abstraction, service reusability, service autonomy, service statelessness, service discoverability, and service composability. The following section briefly analyses the principles and reviews the benefits of their application.

Standardized Service Contract

Services express their purpose and capabilities via a service contract. The standardized service contract design principle is perhaps the most fundamental part of the SO. Great emphasis is placed on specific aspects of contract design, including the manner in which services expect functionality, all data types and data models are defined, and how policies are asserted and attached. Is the constant focus on ensuring that service contracts are both optimized, appropriately granular, and standardized to ensure that the endpoints established by services are consistent, reliable, and comfortable.

The main purpose of the service contract is to hide the complex solution logic, while at the same time providing a standardized service description. By providing a consistent data model the service contract reduces the need for data transformation and hence facilitates efficient information exchanges. The service contract provides both the meaning and the boundaries of the services and thus enables interoperability with other services.

Service Loose Coupling

Coupling refers to a connection or relationship between two things. A measure of coupling is comparable to a level of dependency. Service loose coupling is a condition wherein a service requires knowledge of another service while still remaining independent of that service. Ideally, the application of service loose coupling leads to a service contract that is agnostic from both technology and implementation details, a service context that is not dependent on outside logic, and minimal service consumer coupling requirements (Erl 2008).

Service Abstraction

Abstraction ties into many aspects of SO. On a fundamental level, the service abstraction principle emphasizes the need to hide as much of the underlying details of the services possible. Hiding the solution logic under a service contract envelope enables both the protection of the underlying mechanisms and reduces the complexity of the information exchange. Service abstraction also plays a significant role in the positioning and designing a service composition. Various forms of metadata are used in assessing appropriate extraction. The extraction applied can affect service's contract granularity which influence the ultimate cost and effort of governing this service.

Service Reusability

Reusability is defined as the degree to which a software module or other work product can be used in more than one computing program or software system (IEEE 1990). The reusability principle results in several design characteristics. First, reusability requires the service to be agnostic of the functional context, such technologies, platforms and operating systems. Second, the (internal) service logic needs to be highly generic in order to be used by different service consumers. Third, the service contract needs to be generic and extensible to process a range of input and output messages. Fourth, concurrent access to the service logic further increases the potential of reusability

Service reusability promises added value through repeated uses in different contexts. Further, it increases business agility on an organizational level by enabling rapid fulfillment of future business automation needs through wide-scale service composition (Erl 2008). However, reusability also increases the complexity, cost, effort and time to build the service (Erl 2008). In contrast to single purpose services, reusable services do not easily allow for measurable investments and returns.

Service Autonomy

To carry out the capabilities consistently and reliably, solution logic needs to have a significant degree of control over its environment and resources. The principle of service autonomy emphasizes the extent to which other design principles can be effectively realized in real world production environments by fostering design characteristics that increase service reliability and behavioral predictability. This principle raises various issues that pertain to the design of service logic as well as to the service actual implementation environment.

Service Statelessness

The management of excessive state information can compromise the availability of the service and undermine its scalability potential. Services are therefore designed to remain stateful only when required. Applying the principle of service statelessness requires that measures of realistically attainable statelessness be assessed, based on the adequacy of the surrounding technology architecture to provide state management delegation and deferral actions. Statelessness enables concurrent use of service and enables reusability and thus scalability both individual services and the system as a whole.

Service Discoverability

The service design therefore needs to take the communications quality of the service and its individual capabilities into account, regardless of whether discovery mechanism (such as a service registry) is an immediate part of the environment. Service discoverability is closely tied to the communicative metadata by which the services can be effectively discovered and interpreted. Positioning the services as discoverable IT assets is a key condition for reusability and hence repeatable returns on investments.

Service Composability

As the sophistication of service oriented solution continues to grow, so does the complexity of underlying service composition configuration. The ability to effectively compose services is a critical requirement for achieving some of the most fundamental goals of service oriented computing. Complex service compositions put demands on service design. The complexities need to be anticipated to avoid massive for retrofitting efforts. Services are expected to be capable of participating as effective composition members, regardless of whether they need to be immediately enlisted in a composition.

The principle of service composability addresses this requirement by ensuring that a variety of considerations are taken into account.

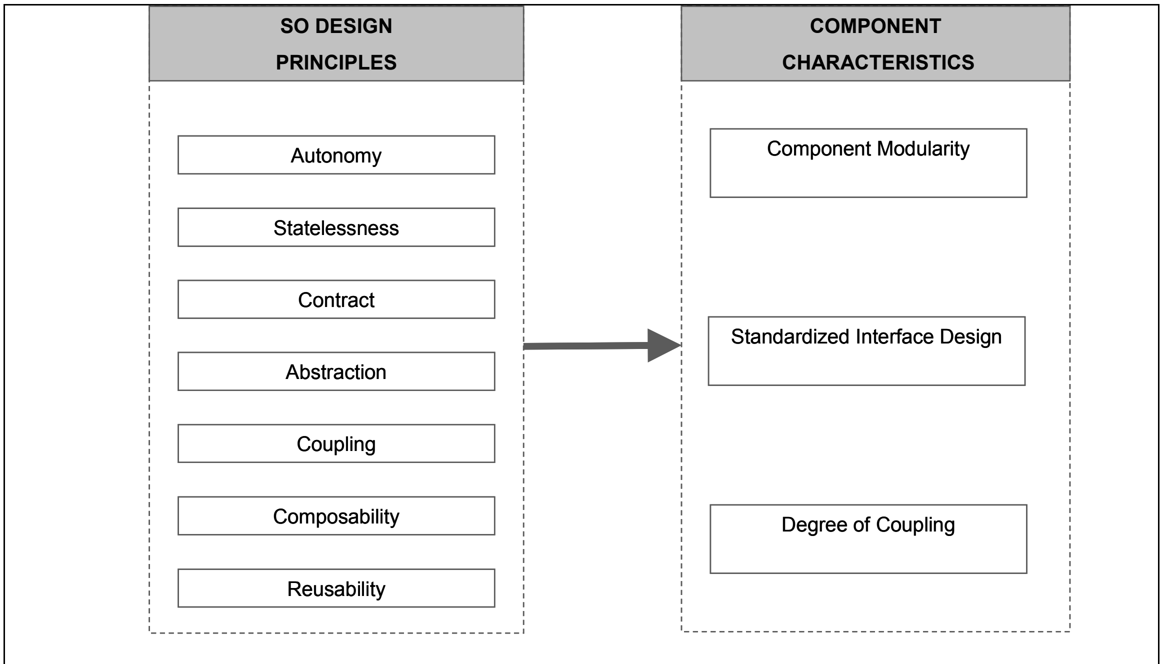

Figure 6: Influence of SOA Design Principles on Component Characteristics

Overarching Principles

Interoperability

Interoperability is fostered by all of the design principles. Each of the principles support or contribute to interoperability in some manner. The standardized service contract, for example establishes a baseline measure of interoperability, whereas the service loose coupling reduces interdependency of services and therefore is more open and interoperable.

A fundamental goal of applying SO is for interoperability to become a natural byproduct, ideally to the extent that the level of intrinsic interoperability is established as a common and expected service design characteristic.

Dynamic Orchestration

Modularity of a system is defined as the degree to which system components can be separated and recombined (Schilling 2000). Service Orientation warrants that that the solution logic is already distributed in the smallest possible unit. Further, interoperability of the services as well as the multipurpose and concurrent layout of the services also enables new forms of recombination or assembly mechanisms. Contrary to objects of past programming paradigms, Service Orientation allows for the services to be orchestrated in a dynamic fashion. This dynamic behavior of service composition and instant adaptation to changing, requirements, context and environments is the key difference to prior computing paradigms.

Summary

Service orientation is a design paradigm that ensures specific component and architecture characteristics that enable the creation of *on demand systems.* The key system characteristics identified are modularity, loose coupling and interoperability. A consistent application of Service Orientation will lead to on demand systems that can consistently adapt to changes to the environment by reassembling services. The composition of the services is envisioned to be of automated nature. But until services are available and a market for services is established, the composition of services will depend on the competence of the participating human actors.

CHAPTER IV: IMPACT OF SERVICE ORIENTATION ON THE ALIGNMENT OF IS ARCHITECTURE AND TURBULENT ENVIRONMENTS

Introduction

The IT capability of an enterprise has long been viewed as an enabler for analyzing market and enterprise data and supporting the decision process. Most IT systems were originally designed to perform standardized processes that were aligned with the static information inputs of orderly and predictable market environments. However, the proliferation of global communications architecture and the subsequent linkage of markets and enterprise have changed the nature of competition. Rather than competing in traditional markets based on assets or scale economies, enterprise find themselves in volatile markets where the market structure, market participants as well as offerings constantly change. In this information-driven economy, the volume of information grows exponentially, while at the same time, veracity of information becomes harder to confirm. Decision makers are forced to make real-time decisions while often being overwhelmed with identifying the relevant information and deciding on the right course of action. Dealing with the environmental complexity requires enterprise to build new organizational capabilities and to employ new strategic processes.

The increasing complexity of the turbulent environment demands agile enterprise that can create and exploit digital options (Sambamurthy et al. 2003). In order to achieve superior financial performance, an enterprise has to create options and needs to translate them into a complex action repertoire that can match or overmatch the environmental complexity. In that context, IT competence, composed of the underlying dimensions of IT capabilities and IT investment, is considered to be the main source for creating digital options (Sambamurthy et al. 2003). While the positive impact on of IT investments on performance and productivity has been demonstrated (i.e. Hitt and Brynjolfsson 1996, Bharadwaj et. al 2000), less attention has been paid to research on the actual IT artifact and its influence on IT capabilities and higher order constructs.

This research is a bottom up approach to explain enterprise performance in turbulent environments by viewing all layers of the enterprise as systems and the enterprise itself as a "*system of systems*". This chapter identifies research that has examined the role of the IT artifact in *alignment and aligning* with both the internal business structure and strategy and summarizes the prior findings. The second focus of the literature review is the investigation of the effect of the turbulence of the external environment on the alignment process. The findings of the literature review and the previously identified system characteristics are then integrated into a new theoretical model. The theoretical model explains how system characteristics influence the alignment in turbulent environments and identifies system configurations that perform best in different degrees of environmental turbulence.

The chapter proceeds by validating the proposed relationships by analyzing the outcomes from a computational model. The main findings of the experiments are a confirmation of the proposed relationships - Information System Architectures that have service oriented system characteristics perform better in aligning with environments, regardless of the degree of turbulence.

Literature Review

This section reviews the prior research and focuses on identifying the role of the IT artifact in the alignment of information systems in the context of turbulent environments.

Information Systems Alignment

Early approaches devised top-down strategic planning models based on the assumption that an IS strategy can be planned and is often closely associated with the business strategy. King determined that there is an organizational strategy set, composed of mission, objectives and strategy, and a MIS strategy set, including system objectives, system constraints and system design strategies (King 1978). Overall this view can be summarized as the alignment of static IS and business plans/strategies. The clear focus of this view is the formalization of an IS strategy, since the early literature does not hint at potential implementation issues of alignment. In retrospect, researchers (Broadbent and Weill 1993; Chan et al. 1997) dubbed this alignment between business and IS strategies "strategic alignment."

At the same time the structural alignment view developed (Ein-Dor and Segev 1982). Structural alignment stresses the importance of structural fit between IS and the business, specifically in the areas of IS decision-making rights, reporting relationships, provision of IS services and infrastructure, and the deployment of IS personnel. Ein-Dor et al. (1982) hypothesized that organizational context variables such as size, time frame, ,and climate toward MIS influence IS structure. It was also assumed that organizational structure is hard to change, making IS structural alignment a static event, rather than a continuous or dynamic process, since the IS structure can only be aligned once to the static organizational structure.

Henderson et al. (1993) proposed a model that represents the dynamic alignment between the business and IS strategic contexts, stressing the necessity for both strategic and structural alignment. In their view, strategy involves "both formulation (decisions pertaining to competitive product market choices) and implementation (choices that pertain to the structure and the capabilities of the firm to execute its product market choices)" (Henderson and Venkatraman 1993). The conceptual model is based on the concepts of strategic integration and functional integration as a way of assessing the range and interrelationships of the strategic choices that managers face. The strategic choices of an organization are framed in terms of external domain and internal domain. The external domain concerns the business area a company competes in. The internal domain concerns the choices regarding logic of the administrative structure, the rationale for business process design and the acquisition and the development of human resources (Henderson and Venkatraman 1993). The authors also identify two distinct functional domains: Business and IT. The authors argue that alignment should involve at least four domains of strategic choice where functional domains and strategic domains intersect: business strategy, organizational infrastructure and processes, IS strategy, and IS infrastructure and processes. Sabherwal et al. (2001) later argued that, besides the four proposed dimensions, there is also cross-dimensional alignment between business structures and IS strategy and business strategy and IS structures that have different implications in terms of how alignment will impact the process of change over time.

The position of the IT organization in the IT marketplace, which the authors name "IS strategy," includes three sets of choices:

1. IT scope which considers specific IT that either support current business activities or could shape new business strategy options,

2. Systemic competencies concerning the attributes of any IT that could impact current or future business strategy and

3. IT governance which is described as the mechanisms required to obtain IT competencies necessary from the market.

IS infrastructure and processes describes the organizational position where the internal domain intersects with the IT functional domain. It consists of IS architecture, IS processes and IS skills. According to Henderson et al. (1993), those choices pertain to the development of knowledge and capabilities of individuals. Congruent with IS strategy, business strategy includes business scope, distinctive competencies, and business governance. Similarly, the components of organizational infrastructure and processes mirror those of their IS counterpart: administrative infrastructure, processes and skills.

Besides identifying the different organizational positions or quadrants, the main contribution of Henderson et al.'s model is the explanation of the interrelatedness of the different quadrants. On the internal domain or horizontal level, operational integration connects business and IT. The model highlights the importance of the coherence between the organizational requirements and the delivery capability within the IS function. The related external link is termed strategic integration. It deals with ensuring that the IT capabilities support current and shape new business strategies.

The authors conclude their propositions by converging the assumptions and findings of prior literature. In particular, the authors show that there can be reciprocal relationships between the four different domains. The relationship between the domains is represented through different perspectives that could lead to change of either IS or business structure. Effecting a change in any single domain requires the use of three out of the four domains to assure that both strategic fit and functional integration are properly addressed. A total of 12 perspectives (which encompass three of the four domains) have been identified and described in the literature (Luftman et al. 1993; Papp 1999).

While the strategic alignment model provided an integrated model of the formerly opposing views of strategic and structural alignment, there are limitations to the theory. Sabherwal et al. (2001) pointed out that the model still only incorporates a cross-sectional or static view of alignment. In the same line of reasoning Ciborra, reflects that "Strategic alignment is a theoretical model (Ciborra 1997). Its abstract geometric representation does not reflect reality. In the real world, strategy is more tinkering than thinking and technology is drifting rather than being stable (Ciborra 1991). Another limitation of the model was the lack of operationalization of the alignment measure (Brown and Magill 1994; Chan et al. 1997).

The strategic alignment model provided a rich basis for both theoretical and empirical research. Researchers have proposed, refined, and debated models for studying the fit of competitive strategies with various IS concepts (e.g., (Luftman and Brier 1999; Papp 1999; Peppard and Breu 2003)). However, the development of detailed operationalized models for measuring the strategic fit of the capabilities created by a firm's IS has been hindered by limitations of the theories employed (Ciborra 1997). The literature has used alignment and fit interchangeably although they are two different concepts. Alignment is the process of transforming intended strategies, structures or processes into realized capabilities, whereas fit measures the results of this process. This section focuses on different operationalizations of both alignment and fit in both the external and internal domains in Henderson et al.'s model.

Strategic Alignment

Among the four quadrants, business strategy is the most widely studied. Miles et al. (1978) identified three strategic configurations known as defenders, prospectors, and analyzers, which served as the basis for numerous empirical studies in the IS strategy literature (Brown and Magill 1994; Sabherwal and Chan 2001; Zahra and Pierce 1990, Miles et al. 1978). Having identified an organization's strategic configuration, researchers proposed to operationalize the organizational fit between the particular configuration and the corresponding support through the IS capabilities by calculating the Euclidian distance between the ideal (or intended) and the reported (or realized) values (Venkatraman 1989a). Sabherwal et al. (2001) used this methodology to assess alignment and found that alignment does not always lead to better business performance. Chan et al. (1997) used the term strategic orientation as a synonym for realized strategies. The authors equated IS strategic alignment with the fit between the business strategic orientation (STROBE) and IS strategic orientation (STROPIS) (Venkatraman 1989b). They found that strategic alignment is best modeled as a moderation construct rather than a matching construct, which implies that there is a multiplicative effect between business strategic orientations and IS strategic orientation. In sum, the research has provided valid measurements for business strategic fit based on the Miles et al. (1978) model. However, there are conflicting results of its impact on firm performance.

Structural Alignment

The degree of fit of functional integration concerns the alignment of the internal business and IS structure. The business organization quadrant has been the subject of extensive research. In their review of the literature Brown et al. (1994) introduced the concept of contingency fit. The prior literature had shown that organizational variables such as firm size and corporate or business strategy, as well as structural variables such as locus of decision making authority and business unit autonomy, had been hypothesized to influence the functional integration of the IS structure. In order to better formulate the research model the authors introduced patterns of variables or "gestalts" to investigate simultaneous impacts of potential antecedents. They further established the IS functions of management of IT and management of the use of IT as loci of responsibility. As such, Brown et al. address IT governance as a structural matter, rather than a strategic matter as it is proposed in the Strategic Alignment Model. This deviation seems plausible since the potential antecedents for IS structure are both internal (IS organization and IT investment, overall organization) and external (external environment). The study finds that the IS structure is mainly caused by organizational variables such as corporate vision, corporate strategy, firm structure and culture, strategic IT role and senior management of IT. Yet, they also found support of a reciprocal relationship where perceived deficiencies in IS performance and an increased belief in the strategic role of IS can lead to a new organizational structure. Chan also analyzed structural alignment (Chan 2002). She concluded that there is no standard organizational configuration in terms of structural alignment. Eight case studies showed that preconditions such as strong business skills, customer orientation, formalization of the CIO role, IS steering committees and relationships with external IT consultants did not necessarily need to be in place to achieve alignment.

Dynamic View of Alignment

Chan (2002) hinted at the dynamic nature of both structural and strategic alignment. Although not considered in the original Strategic Alignment Model, the dynamic nature of alignment has increasingly gained importance (Peppard and Breu 2003; Peppard and Ward 2004; Sabherwal et al. 2001). Chan found that IS structure needs to be flexible in order to quickly and constantly adapt to both internal business structure and external business strategy changes.

The original Strategic Alignment Model does not incorporate a longitudinal view. Ciborra has been among the first researchers to point out the dynamic nature of alignment (Ciborra 1991; Ciborra 1997; Ciborra 1998). His main argument on the dynamic nature of alignment concerns diversions from strategy: change of plans, surprises, opportunistic adjustments, manager's improvisations (Ciborra 1996). At the same time, the IT artifact also changes in a punctuated manner with unexpected outcomes and frequent adaptations and reinventions. Thus both the business dimensions and the IS dimensions are constantly changing. Sabherwal et al. (2001) were the first to provide empirical support for Ciborra's theories. The authors argue that alignment is only temporary since the environment continues to change. Further, there is a tendency in organizations to be satisfied with the status quo of alignment. The authors suggest that a punctuated equilibrium model applies to the dynamics of alignment. The model recognizes the importance of a changing external environment by both accounting for evolutionary periods with only incremental change and revolutionary periods where structures are completely transformed. The authors equate those "deep" structures with the strategy set of IS management, since they reflect the organization's basic choices in terms of strategies and structural arrangements in business and IS domains. They found support for the model and thus showed that alignment varies over time. Still the model has only limited predictive power since they conclude that evolutionary periods may or may not be characterized by high alignment and revolutionary periods do not necessarily increase alignment.

Peppard et al. (2003) propose a coevolutionary view of alignment: "Coevolutionary thinking appreciates the embeddedness of organizations in a complex socio-cultural and historical context, where forces of change and interactions conflux and reverberate. It also allows a dynamic view of the processes and forces, which act upon the organization and its environment" (p. 745). They define coevolution as "the joint outcome of managerial intentionality, environment, and institutional effects". At the same time they admit that the proposed model can hardly be tested empirically with the conventional research methods since it involves multi-level effects, multidirectional causalities, non-linearity, positive feedback path and history dependencies and smooth vs. rugged fitness landscapes.

Alignment and Performance

From the early literature, strategic alignment is argued to create competitive advantages and thus to enhance business performance (Earl 1989; Ein-Dor and Segev 1982; Luftman et al. 1993; Niederman et al. 1991; Powell 1992; Venkatraman 1989b). Alignment is theorized to enable a firm to maximize its IT investments by aligning it with its business strategies and plans, leading to greater profitability (Chan 2002; Chan et al. 1997; Premkumar and King 1991). Despite the calls for empirical research on the alignment performance relationship, only a few studies have looked at this relationship.

Chan et al. 1997 were among the first to link IS strategic alignment of realized domains with business performance. They found that IS strategic alignment directly and indirectly, through its influence on IS effectiveness, impacts business performance.

Kearns and Lederer (2000) also investigated the alignment performance relationship (Kearns and Lederer 2000). As an extension to the prior research, they investigated both directions of business and IS alignment. The authors found significant support for their hypothesis that alignment of IS plans with business plans creates a resource for competitive advantage. However, they only found partial support for the relationship between the alignment of business plans and IS plans. The multi-respondent design provided mixed results, raising the question whether individual responses can represent alignment of a business unit or firm. Papp investigated an objective performance measure in order to overcome the shortcomings of the self reported measures (Papp 1999). The research shows that performance can be expressed in terms of return on investment, growth in earnings per share and pre-tax income. However there was no support for the proposed moderation effect for alignment.

The prior research on alignment has provided several contributions to IS theory. First, there are characteristics of IS and business that influence the alignment of the two structures. Second, alignment is a process that is dynamic and longitudinal in nature. Third, the process is dependent on the turbulence of the environment. However, the three findings have not been investigated in a holistic approach.

Complementary View and Resource-Based View of IT

One of the most dominating topics in the recent IS research is whether investment and use of information technology (IT) is resulting in higher productivity. This so-called productivity paradox stimulated more rigorous scientific analyses of the relationship between IT and productivity (Brynjolfsson 1993; Brynjolfsson and Hitt 1996). These studies revealed positive and significant impacts from IT investments at the firm and country level. Moreover, researchers soon realized that investment in IT is only a necessary condition for improved business performance. Organizational factors such IT management skills and the quality of IT labor, which were later summarized as the IT capability of a firm, were recognized as potential mediating factors in the IT investment – business value relationship (Brynjolfsson 1993). The role of the IT capability as a complementary resource has been brought forward to explain why IT can create a competitive advantage (Brynjolfsson et al. 1996)

The complementary view of IT was further refined by the resource-based view (RBV) of the firm (Bharadwaj 2000). The RBV states that competitive advantage is rooted in the deployment and use of idiosyncratic, valuable and inimitable resources and capabilities. The ability to reconfigure internal and external resources is the core concept of the dynamic capabilities research (Teece et al. 1997). The context of dynamic capacities is a surprisingly changing or turbulent environment, which enterprise need to sense and respond to with competitive maneuvers. The IT competence is considered a driver of creating digital options that influence the enterprise's agility, which is considered a dynamic capability (Sambamurthy et al. 2003).

Dynamic capabilities are concerned with the organizational capabilities of a firm that are leveraged to adapt to a changing environment. As such, IT is not considered a dynamic capability. However, IT plays an important role in enabling sensing and response capabilities of the firm (Sambamurthy et al. 2003). Recent literature on enterprise agility has stressed that IT competence can drive the development of digital options that can enhance the number of actions and the complexity of actions available to an enterprise for responding to turbulent changes in the environment (Overby et al. 2006).

The IS literature suggests that enterprise need to be able to sense changes in the turbulent business environment and then respond to those changes accordingly to achieve competitive innovation and competitive performance. IT competence is a crucial driver to achieve this kind of enterprise agility in turbulent business environments (Sambamurthy et al. 2003). While it is proposed that a truly agile enterprise will gain competitive advantage if it possesses both superior sensing and response capabilities (Overby et al. 2006), little research has both theoretically and empirically investigated the IT and organizational architecture principles that underlie this process.

Executing competitive maneuvers requires more than sensing and responding capabilities. An intermediate step where resources are redesigned and/or reconfigured is also needed to create a response. The reconfiguration of internal resources is a key aspect of the dynamic capability theory, in which the agility construct is rooted (Overby et al. 2006; Teece et al. 1997). The IS literature has approached reconfiguration and the refigurability of processes from several different angles. Pavlou et al. proposed a distinction between reconfiguration as the deployment or goal process by which new configurations are achieved, versus the enabling processes that facilitate reconfiguration (Pavlou and El Sawy 2006). They proposed internal enablers that facilitate reconfiguration such as market orientation, absorptive capacity, collective mind and coordination capability. Yet, IT architecture was not included in their discussion of reconfiguration enablers.

While the agility literature has discussed the importance of sensing and responding, little emphasis has been placed on the intermediate step of reconfiguring the IT resource to create the response capability. IT competence has been defined as the organizational base of IT resources and capabilities, which describes the ability to convert IT assets and services into strategic applications. The majority of the IT competence dimensions relates to the organizational capabilities, such as IT human capital, quality of IT capabilities and nature of the IS/partnerships.

Broadbent et al. (1999) were among the first to investigate the impact of IT infrastructure capabilities on the reconfiguration capability of the firm. In the context of Business Process Redesign, they investigated the impact of firm-wide infrastructure service on the success of organization reconfiguration. They defined the infrastructure capability as a degree of range (process complexity) and reach (communication span) of the infrastructure service. They concluded that more complex redesigning efforts need to be matched a with high infrastructure capability in order to be successful. The attributes of global connectivity and reliability (subsumed as quality of IT) of the IT infrastructure are part of the firms' IT competence (Henderson 1990). In both studies, IT is seen as a complementary resource that aids the change process and a one-dimensional causation between organizational and IS structures is assumed. Ross et al. (Ross and Goodhue 1995) summarize the role of IT as to having no value apart from the processes it supports.

Malone et al. (1999) approached the influence of IT infrastructure from a different point of view. They argued that IT is driving the modularization of business processes and thus hinted at a more active role of IT in the process of recombination of systems (Malone et al. 1999).

The newer theories presented emphasize that there is a strong relationship between the extent of the system characteristics that result in reconfigurability and their impact on the alignment in turbulent environments. However, the linkages and antecedents of those relationships have yet to be examined. Hence I propose an approach that investigates the influence of generalizable system characteristics on the alignment in turbulence environments.

The Nomological Net of the IT Artifact

Implementing service oriented systems is recognized as one of the premier means to achieve enterprise responsiveness. In a recent survey, 90% of Fortune 500 CEOs expected to transform their enterprise towards responsiveness. According to a Gartner study, Service Oriented Architectures are currently used in the development of more then 50% of new mission-critical operational and business processes. Moreover, it is recognized that SOA will change both IT architectures and organizational designs, and that the resulting “on demand business” will change the nature of competition. Despite all the high expectation in SOA, there is confusion of how to define and characterize the IT artifact.

The term SOA originally stems from the Computer Science literature. Service Oriented Architecture refers to the platform architecture that underlies the service design and creation. Similar to the definition of IT infrastructure by Broadbent et al. (1999), SOA is typified by technologies that allow for the creation, execution and evolution of solutions built in compliance with service orientation design principles (Erl 2007).

Service orientation is a design paradigm comprised of a specific set of design principles which result in distinct component characteristics, systems attributes and interactions between components and characteristics (Tien and Berg 2003). In the context of service orientation, a service can be defined as a task that does not overlap with associated tasks. A service can provide a collection of capabilities, which are grouped together because they relate to the functional context established by the service. In summary, SOA and service orientation (SO) are the main factors for creating and executing services. SOA creates the platform or environment for the creation and execution of services, while service orientation governs the design principles of both the environment (SOA) and the services. Figure 5: Basic Relationship between Services, Service oriented Architecture, and Service Orientation, adopted from Erl (2007) summarizes these relationships.

Service orientation observes several design principles that result in services or components that have specific attributes. A service oriented component is agnostic of the context and provides stable and reliable functionalities. The design principles of autonomy, statelessness and abstraction warrant component functionality. Component modularity is an equally important service characteristic. Modularity is concerned with the standardization of the component interface design and a proper description of the component's functionality. Relationship or interconnection attributes are the third measurable component characteristic. Interconnection is a direct consequence of coupling. In the context of service orientation, loose coupling is desired, since components need to be connected and disconnected based on the changing functional context. A summary of the described relationships is depicted in Figure 2.

Systems can be analyzed by examining its various components in terms of component characteristics, attributes and relationship between components. (Tien and Berg 2003) describe systems in the service context as:

[A] system [can be defined as] an assemblage of objects united by some form of regular interaction or interdependence … In regard to its elements, a system can be detailed in terms of its *components*, composed of people, processes and products; its *attributes*, composed of the input, process and output characteristics of each component; and its *relationships*, composed of interactions between components and characteristics. [pp. 23-24]

The extent of the components' characteristics directly impacts intra-component relationships and the overall system characteristics. High degrees of modularity, loose coupling and interoperability are the main outcomes expected of system design based on service orientation (Erl 2007).

Flexibility of the IT architecture has gained importance in IT systems planning as a driver of business value (Byrd 2000). Flexibility is defined as the degree to which a system can incorporate change. Allen et al. (1991) noted that flexibility and efficiency are the most important criteria in selecting any IT system or application. The service oriented design meets that need because it creates systems that are flexible. The component integrity, modularity and upgradeability create system flexibility as defined by Garud et al. (1995). Scalability, integrity, reliability and availability are system characteristics linked to the quality of an IT architecture (Castro et al. 2002). The influence of service orientation on system characteristics sets the stage for the theoretical model. As mentioned before, Information System characteristics influence the IT capabilities that enable the enterprise to create digital options. Moreover, IT plays an integral role in the modularization and integration of business processes, which enables operational agility (Sambamurthy et al. 2003). Creation of both digital options and operational agility requires an IT architecture that is adaptable. Service oriented systems are designed for adaptability and hence will lead to the creation of digital options.

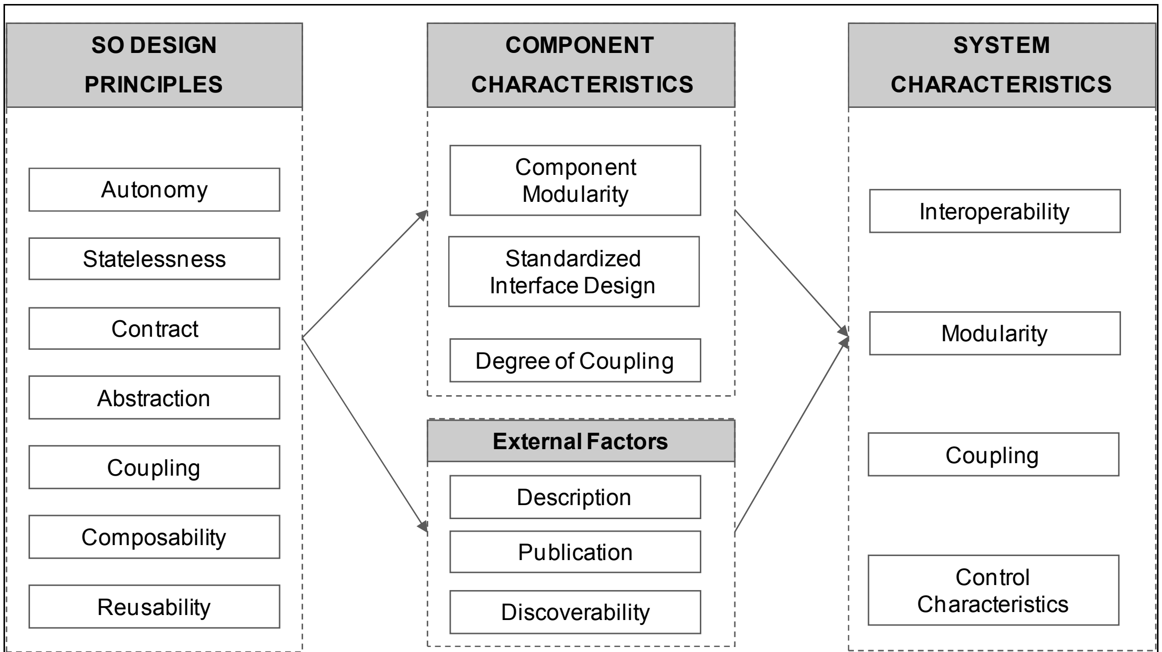

Figure 7: Influence of SOA Design Principles on System Characteristics

Theoretical Model

The strategy literature proposes a theory of substitution to explain the impact of modular technological and organizational designs. Garaud et al. (1995) proposed that technological systems that are based on architecture of compatible components, lead to system characteristics that possess integrity, modularity and upgradeability. They propose that such systems derive economies of substitution from reduced performance slippage, a quick amortization of design cost through the increasing benefit of system reuse and reduced incorporation and search cost. Economies of substitution explain the direct benefits associated with the implementation and use of modular systems.

Service oriented systems increase the active impact of IT architecture on reconfiguring business processes. Rather than complementing ongoing business practices, the systems actively change the way that business is being done. The impact is twofold. Implemented as a technological capability, service oriented systems support the rapid, low-cost development and easy composition of distributed applications. Service oriented systems are designed to continuously and dynamically adapt to changing demands of an enterprise. Second, service orientation will also spur the redesign of business processes into services that fulfill specific needs that are demanded by a constantly changing environment.

As proposed earlier, service oriented systems indirectly affect business performance by serving as enablers of reconfigurability, which leads to alignment with the demands of the external environment. The scope of this research is an examination of the influence of the system characteristics modularity, coupling and interoperability in the context of turbulent environments.

Modularity

The concept of modularity has gained increasing attention in the management and IS literature (Benbya and McKelvey 2006; Schilling 2000). Modularity has been identified as both a degree of system robustness to internal reconfigurations (Garud and Kumaraswamy 1995) and the degree to which the components of a system can be separated and recombined (Schilling 2000). Schilling's definition of modularity as a continuum describes the degree to which a system's components can be separated and recombined, and it refers to the degree to which the "rules" of the system architecture enable (or prohibit) the mixing and matching of components" (Schilling 2000). Hence, modularity is a function of the degree of separability of components and the degree of recombination of the system.

Simon (1962) introduced the concept of modular design. He argued that systems consist of "nearly disposable subunits" that are mostly independent form top-down control and interdependencies from other subunits. In other words, components are autonomous and agnostic to their functional context, the system and the external environment in which they operate. Both the conditions of autonomy and agosticity of the components serve as necessary conditions for the system to evolve faster and toward stable, self-generating configurations.

Modularity also creates flexibility. Flexibility encompasses various meanings that include both temporal and intentional dimensions (Evans 1991). Service orientation encompasses several instances of flexibility. First, it creates versatile systems that ex-ante can create offensive capabilities. This capability is based on the ability to modify the systems by exchanging components. Resilience is the second meaning of flexibility that is relevant to service orientation. Because the components are designed to only minimally rely on other components, the system can operate despite the temporal loss of individual components. Service oriented systems are designed for modularity. Thus, service oriented systems provide the benefit of modularity to firms' IT architectures and overall reconfigurability.

Proposition 1: Modularity positively influences the alignment of IT architecture and environment.

Loose Coupling

The versatility attribute of flexibility enables a system to reconfigure its components based on changes in its environment. Flexibility allows an enterprise to build dynamic capabilities and enhance enterprise agility (Sherehiy et al. 2007). From a standpoint of reconfigurability, flexibility should enable systems to accommodate a variety of environmental disturbances and situational contexts. Flexibility is also a direct benefit of the design of the connections between components or organizational units. Weick (1976) formulated the subject of modular organizational design through the concept of "loose coupling." He observed that loosely coupled systems are characterized by situations where several means can produce the same result – a lack of coordination or absence of regulations.

Proposition 2: Loose coupling positively influences the alignment of IT architecture and environment.

Interoperability

Service oriented systems are designed to interoperate with external systems. The interoperability extends the set of available components to solutions outside of the realm of IT architecture. The integration of outside components increases the number and complexity of potential solutions to changes in the outside environment. Moreover, it enables the architecture to learn and source from external entities, while at the same time focusing on developing expertise in creating services related to an enterprise's core focus (Garud and Kumaraswamy 1995; Sanchez 2000). The ability to draw from more and better-fitting components is the main impact of interoperability on the systems performance and adaptability. By increasing the technological degrees of freedom, the complexity of the turbulent environment can be better matched.

Proposition 3: System Interoperability positively influences the alignment of IT architecture and environment.

The three identified systems characteristics increase the digital options of an enterprise. Loose coupling allows for concurrent manipulation of subsystems without affecting the remaining components and the overall performance of the information systems architecture. Modularity enables testing of new components and the addition of new functionalities. Lastly, interoperability increases the number of digital options by allowing external solutions to be quickly if not automatically integrated. Thus, service oriented systems should align well with turbulent environments.

IT Competence

Prior research on alignment and enterprise agility has identified complementary organizational capabilities and resources that influence the information systems architecture alignment with business structure, business strategy and external market environment. Among the organizational context variables investigated were firm size, organizational structure, (Brown et al. 1994), organizational context (Chan 2002), and individual and other organizational characteristics (Luftman 1999). The resource based view sums up those idiosyncratic and inimitable resources and capacities as dynamic capabilities. In the context of information systems, IT competence is the core capability of a firm that enables use and manipulation of information systems. IT competence includes all the information systems related capabilities of an organization or enterprise. Hence, a high degree of IT competence should lead to better management, manipulation and use of internal information systems, which result in a more effective creation of digital options. As such, IT competence will also lead to better alignment between IT architecture and external environment.

Proposition 4: IT competence positively influences the alignment of IT architecture and environment.

Turbulence

The prior hypotheses have taken the turbulence of the environment into account. The review of alignment claims that the process of alignment is subject to the influence turbulence (Sabherwal and Chan 2001). Sabherwal et al. (2001) identified that that the degree of turbulence, characterized as evolutionary and revolutionary periods, mediates the structural alignment. Moreover, one of the main propositions of the enterprise agility literature is that as environments become increasingly turbulent and they can only be matched by a solution space that is created by digital options. While there is no standard definition of what differentiates a turbulent from a non-turbulent environment, the degree of turbulence impacts how quickly and how well ISA architectures are aligned with the external reality. In more turbulence, organizations need to generate more digital options to match the demands of and align to the changing environment. Assuming that organizations are limited in the digital options they can create, a high degree of turbulence should have a negative impact. Since turbulence is an exogenous variable, it will be used as a control characteristic in the theoretical model. The research model and the research context are depicted in Figure 8.

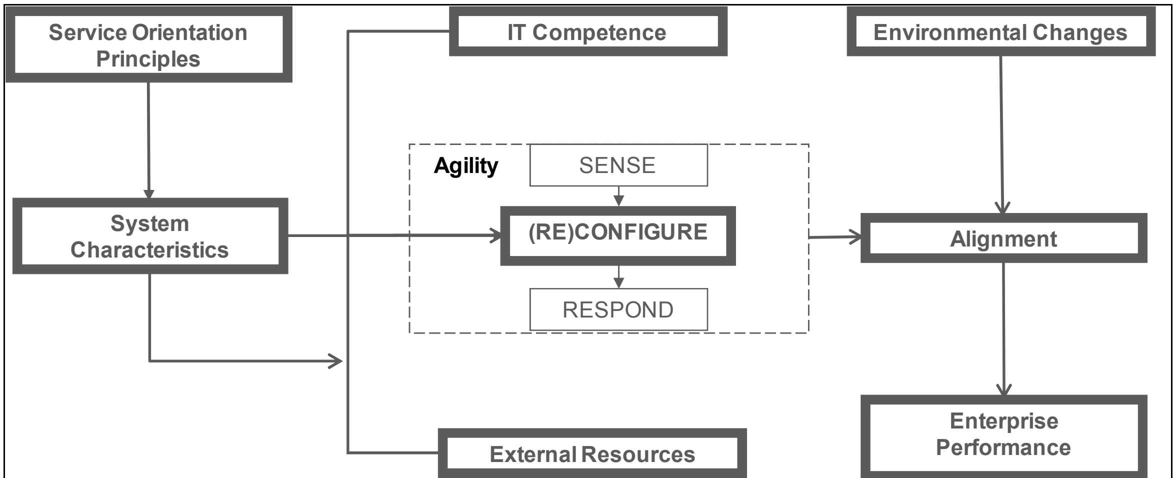

Figure 8: Research Model and Context

Research Design

The computational model examines the impact of organizational Information Systems Architecture (ISA) configurations and their propensity to align to a changing environment. The first section describes the computational model that is used to examine the propositions derived in the previous section. The propositions are then tested in the first set of experiments where the impacts of individual characteristics on the alignment of information systems architecture with the external environment are explored. After the evaluation of the separate impacts, the second experiment examines the simultaneous impact of the idiosyncratic characteristics on the alignment of ISA and External environment.

Model Parameters

External Environment

The environment is modeled similar to March's (1991) construct of external reality as a vector of environmental dimensions (*r*). The vector consists of $m = 10$ dimensions that can take on a trait (*t*) formulated as an integer between 0 and 9. The traits are not ordinal but rather represent the state of the dimension. The external environment can be interpreted as a set of demands that are observed by an organization. For example, the customer needs can change over time. Such a change would be captured in a changing trait in the customer needs dimension on the external environment. The dimensions in the external environment are <u>not</u> designated to any specific real world dimensions. They rather present a generic set of environmental factors that can affect the performance of an organization. The abstraction from specific factors allows the investigation of changes and the rate of change in a multi-dimensional environment. The external environment is subject to changes that are induced by the turbulence probability p_t which determines how frequently the external environment changes.

Information Systems Architecture

The main assumption of the research model is that an information system architecture can be manipulated to be aligned with the changing external environment. The model of the organizational ISA mirrors the construction of reality, with $m = 10$ dimensions ranging from 0 to 9. Each dimension in the ISA corresponds to the respective dimension in the external environment. Coming back to the example of changing customer needs, the corresponding ISA dimension could be a customer relationship management system (CRMS). If customers changed their communications preferences from calling using a phone to subscribing to an RSS feed, the CMRS needs be changed to provide the desired communication channel to the customer. Thus, the ISA dimension needs to align as closely as possible to the trait observed in the external environment.

Outside of the ISA vector, which represents the current configuration of the architecture, there are internal factors that affect the ISA's ability to change. First, there are the systems characteristics that have been identified to influence the reconfigurability of the ISA. The system characteristics are randomly assigned at the beginning of the experiment, are considered to be exogenous, and thus do not change over the course of the experiment.

Coupling of the system (*cp*) is modeled as a single integer from 1 to 9. The values of coupling are ordinal. A value of 1 signifies that ISA dimensions, or subsystems, are on average linked with one other subsystem. If a subsystem is coupled with all other subsystems, *cp* has a value of 9. Hence, *loosely coupled* architectures, which only depend on few other subsystems to function, have a low coupling.

Modularity (*mo*) is also modeled as a single integer ranging from 1 to 9. As with coupling, the values are ordinal. The value describes the concurrency of access to different subsystems. A value of 1 describes a scenario where only 1 of the 10 dimensions can be changed during an adaption cycle. A high modularity value of 9 would allow for concurrent changes of up to 9 subsystems during an adaptation cycle. System interoperability (p_{si}) is modeled a probability ranging from 0 to 0.05. The characteristic describes the probability of substituting a single ISA dimension with the trait of the corresponding reality vector. It can be interpreted as the likelihood for sourcing a single subsystem solution from an external vendor. Hence, the higher the interoperability value, the more likely is a dimension of the ISA to be replaced with the actual value of reality. System substitution (p_{ss}) is the last ISA characteristic modeled. It is the probability that the entire ISA is substituted by the reality vector. This event corresponds to a system update or a purchase of a new system from an external vendor. The probability ranges from 0 to 0.01 since the described events are a fairly rare occurrence (Konsynski and Tiwana 2004).

Aside from the systems characteristics, ISA's are also subject to the organizational and human capabilities to properly align the information systems. For the purposes of the simulation, IT competence (*itc*) has been modeled as a vector ranging from 1 to 9. A high value of IT competence can be interpreted as the availability of those complementary resources that are necessary to manipulate information systems. A low value corresponds to the lack of complementary resources and capabilities.

Table 1: Model Parameters, Definition and Operationalization		
Parameter	**Definition**	**Operationalization**
Environmental Parameters		
Trait	Extent of a dimension of the External Environment	$t = 0 \ldots 9$
Dimensions	Number of dimensions in external environment	$m = 10$
External Environment	Set of environmental dimensions	$r = [t_{r1} \ldots t_{rm}]$
Turbulence Frequency	Probability of change in a dimension	$p_t = 0 \ldots 1$
Idiosyncratic Parameters		
Information System Architecture	Set of architectural dimensions	$ar = [t_{ar1} \ldots t_{arm}]$
Modularity	Degree to which the components of a system can be concurrently reconfigured	$mo = 1 \ldots 9$
Coupling	Degree to which the components of a system are interdependent	$cp = 1 \ldots 9$
Interoperability	Probability to which components of a system can be exchanged	$p_{si} = 0 \ldots 0.05$
Substitution	Probability to which entire systems can be substituted	$p_{ss} = 0 \ldots 0.01$
IT Competence	Information systems related capabilities of an organization	$itc = 1 \ldots 9$
Observed Variables		
Alignment	Variance of differences between *r* and *ar*	$A = \frac{\sum_{k=1}^{n}(r_{kn} - ar_{kn})^2}{n}$
Turbulence	Variance of changes in r	$tu = \frac{\sum_{i=1}^{n}(r_k - \overline{r_k})^2}{n}$

Observed Variables

Turbulence is measured as the variances of actual changes of the dimensions of reality in every cycle. The dependent variable, the alignment between the ISA attributes and the dimensions of the external environment, is measured as the variance of the differences between the corresponding dimensions. An overview of the model parameters is provided in Table 1.

Interaction Mechanism

The objective of every organization is to align its ISA with the demands observed in the external reality. Thus, a successful alignment process would result in a small numeric difference between the values of the dimensions in the external reality and its counterparts in the ISA. Since the values are not ordinal, the direction of the differences is meaningless. However the variance of the absolute differences of one organization across the 10 dimensions provides a meaningful measure of how closely aligned an organization's ISA is with the external environment. Hence, each organization attempts to align the dimensions of its ISA to minimize the variance of the dimensional differences with the external environment.

The alignment process is constrained by the extent of the idiosyncratic systems' and organizational characteristics (i.e. *itc*). In a typical alignment process, the external reality and thus the idiosyncratic differences between ISA and the external environment would be observed. The first option to align would be to seek an external system substitution, which is based on the p_{ss} constraint. The next alignment option would be to change a single dimension by substituting it with the value of the corresponding external environment dimension, a process which is governed by the *si* probability.

After the exhaustion of external solutions, an organization proceeds by internally aligning the ISA. First, it would identify the subsystem that contributes most to the misalignment with the external environment. It then uses its IT competence to change the systems. Since the subsystems are linked to each other, IT competence is needed to resolve those linkages between subsystems. Thus, the value *itc* is reduced by *cp.* The remaining *itc* value then can be used to change the value of the selected subsystem to decrease its difference with the corresponding external environment dimension. The amount of change then gets deducted from the *itc* value. If there are still remaining organizational capabilities (i.e. a positive value for *itc*), another subsystem can be changed likewise, as long as the system is modular enough (i.e. positive *mo*) to allow for concurrent alignments of subsystems.

This process is repeated for all organizations in the experiment. Thereafter, the external environment is updated based on the turbulence probability and the turbulence magnitude. And the alignment process begins anew. The basic interaction mechanism is depicted in Figure 9.

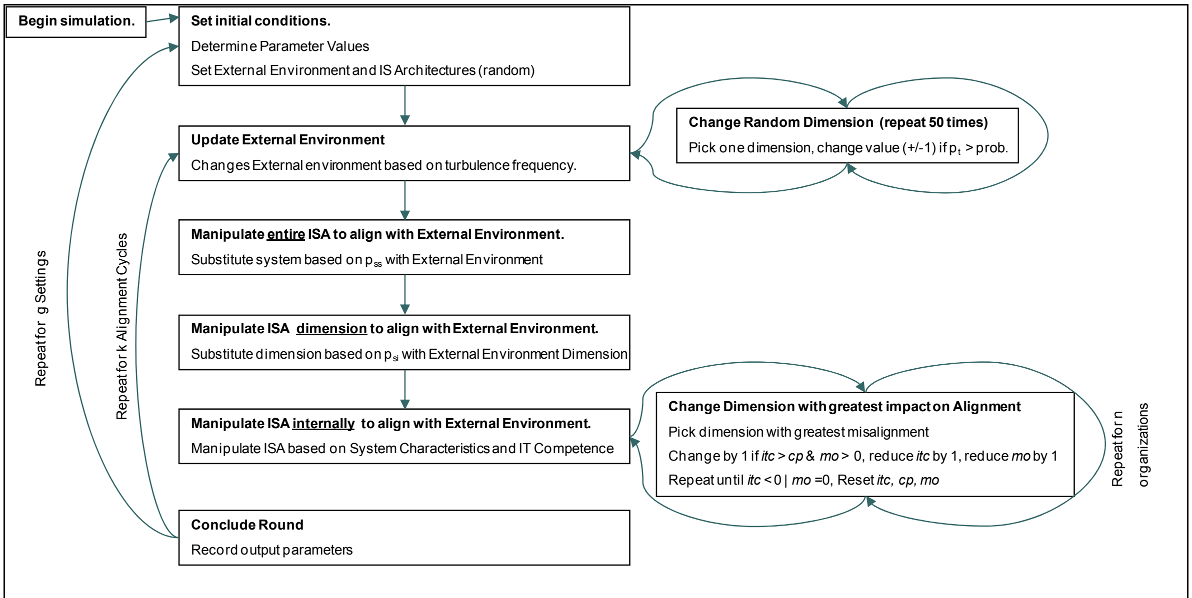

Figure 9: Interaction Mechanism

Table 2: Parameter Values For Separate Experiments

Parameter	Low	Medium	High
Turbulence	0.25	0.5	0.75
Modularity	2	5	8
Coupling	2	5	8
System Interoperability	0.125	0.025	0.0375
System Substitution	0.00625	0.0125	0.025
IT Competence	2	5	8

Experiment I – Separate Effects of Idiosyncratic Characteristics

In the first set of experiments examines the separate effects of individual idiosyncratic characteristics. The experiments are conducted by varying one characteristic at a low, medium and high level and observing its impact in low, medium and high degrees of environmental turbulence. All other characteristics are held constant at a medium level. The parameter values corresponding to the respective levels are depicted in Table 2.

Data Analysis

Modularity

The impact of modularity on the alignment is inconclusive. Both a high and a medium degree of modularity have the highest impact in a low turbulent environment.[1] In the medium turbulence scenario, all three degrees of modularity have same impact on alignment in both the medium and high turbulence environments. The p values for the means of the three degrees of modularity in this scenario are all above 0.8. In the high turbulence scenario, the medium degree of modularity causes the best alignment of ISA and external environment[2]. The results suggest that the modularity construct does not have a linear impact on alignment but that the effect changes in different degrees of environmental turbulence. The results of the experiment are depicted in Figure 10.

[1] In the low turbulence scenario, the alignment values for medium and high Modularity are not statistically different from each other. (Two sample t test, p value =.97)

[2] In the high turbulence scenario, the alignment values for low and high Modularity are not statistically different from each other. (Two sample t test, p value =.16)

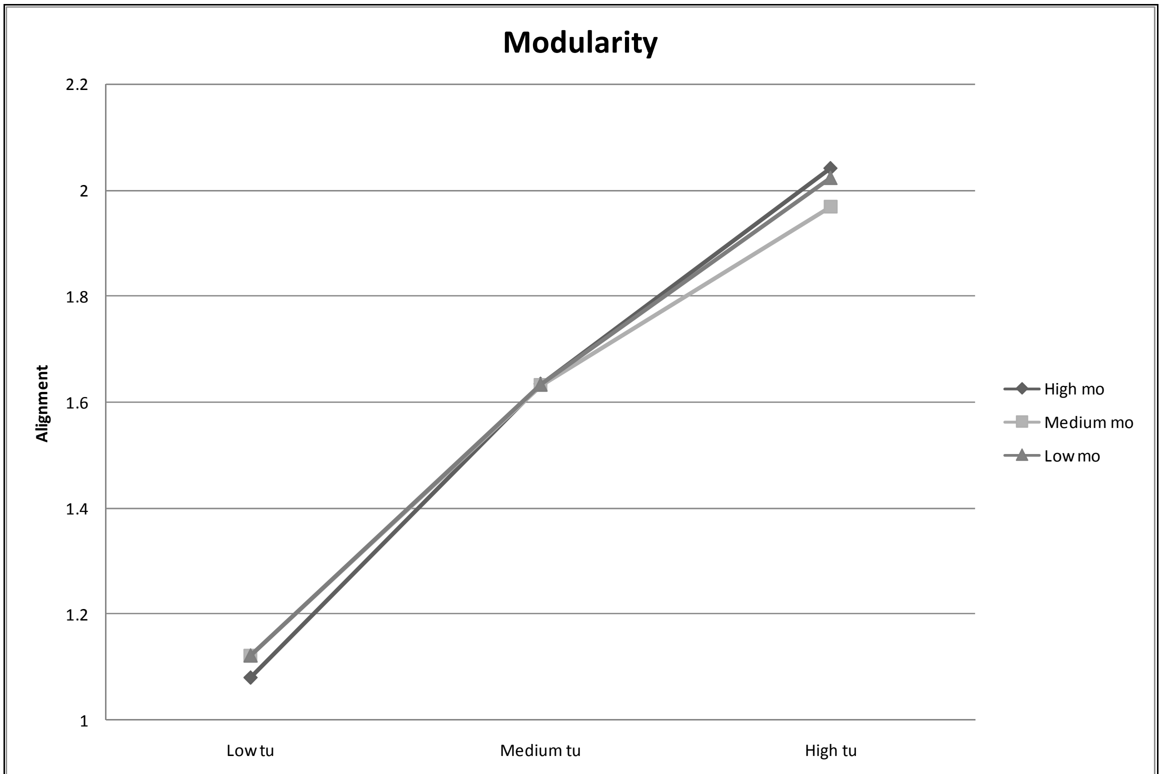

Figure 10: The Impact of Degrees of Modularity in Different Degrees of Turbulence

Coupling

Coupling has the proposed effects on alignment. A low degree of coupling increases alignment in all three turbulence scenarios. Thus, the effect is not mediated by the degree of environmental turbulence. The less interdependent subsystems are, the better the ISA can align with the external environment. The results of the coupling experiment are depicted in Figure 13.[3]

[3] In the both the high and medium turbulence scenario, the alignment means for medium and high coupling are not statistically different from each other. (Two sample t test, p values =.45 ; .28)

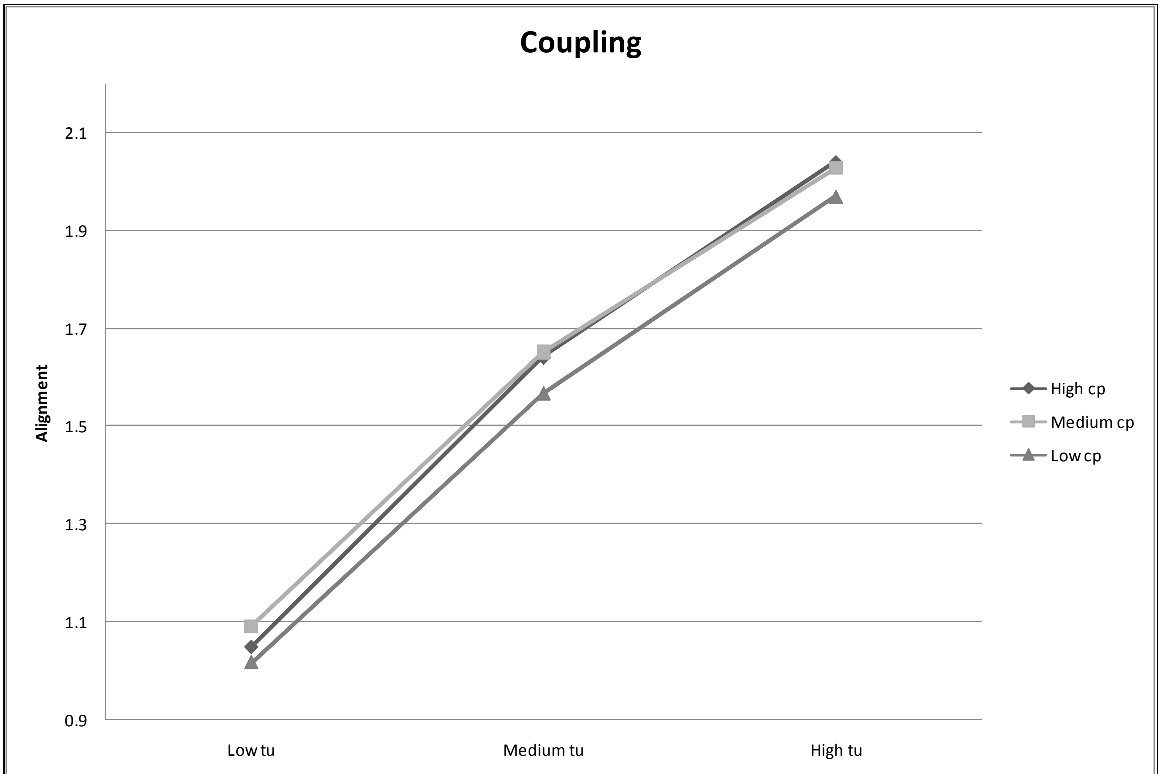

Figure 11: The Impact of Degrees of Coupling in Different Degrees of Turbulence

System Interoperability

The experiment investigating the impact of System Interoperability on the alignment of ISA and external environment provides interesting results. The ability to substitute individual dimensions increases in importance as the degree of turbulence increases. In low turbulent environments, a low propensity of substituting subsystems provides the best alignment of the ISA with the external environment. The medium degree of System Interoperability provides the highest alignment in the medium turbulence environment. In the highly turbulent environment, the best alignment is achieved with a high degree of system interoperability. The results of the experiment are depicted in Figure 12.[4][5]

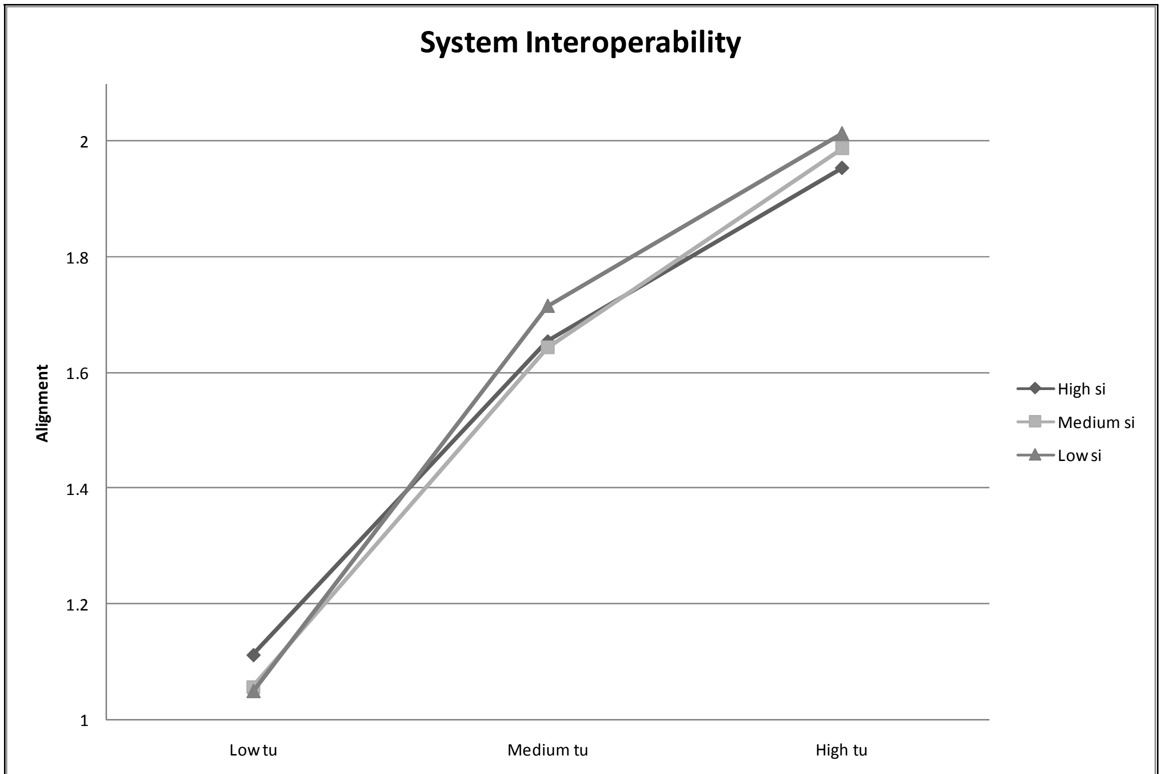

Figure 12: The Impact of Degrees of System Interoperability in Different Degrees of Turbulence

The observed results confirm the notion that closed systems that are designed for a certain static environment are more efficient, while interoperable systems perform better in turbulent environment. We will revisit this finding in the chapter discussion section.

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[4] In the low turbulence scenario, the alignment values for low and medium System Interoperability are not statistically different from each other. (Two sample t test, p value =.56)

[5] In the medium turbulence scenario, the alignment values for low and high System Interoperability are not statistically different from each other. (Two sample t test, p value =.55)

System Substitution

The examination of the impact of System Substitution on the alignment of ISA and external environment also provided mixed results. In the low turbulence environments the medium degree of System Substitution yielded the best alignment[6]. In the medium degree of turbulence the highest degree of system substitution resulted in the best alignment[7]. In the high turbulence environment, both the medium and the high degree of System Substitution resulted in the best alignment. In this scenario both means values of alignment are not statistically different from each other (Two sample t test, p value =.39). Hence, it can only be concluded that across the different levels of turbulence a low degree of systems substitution leads to worse alignment than both the medium and the high degree of System Substitution.

IT Competence

IT competence shows the expected effects which are depicted in Figure 14[8]. A higher degree of IT competence leads to lower variance of differences, and thus to a higher alignment between ISA and external environment. The effect is moderated by the

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[6] In the low turbulence scenario, the alignment values for low and high System Substitution are not statistically different from each other. (Two sample t test, p value =.17)

[7] In the medium turbulence scenario, the alignment values for low and medium System Substitution are not statistically different from each other. (Two sample t test, p value =.24)

[8] In the high turbulence scenario, the alignment values for low and medium IT competence are not statistically different from each other. (Two sample t test, p value =.23)

degree of turbulence in the environment. The higher the environmental turbulence, the smaller is the effect of IT competence on the alignment.

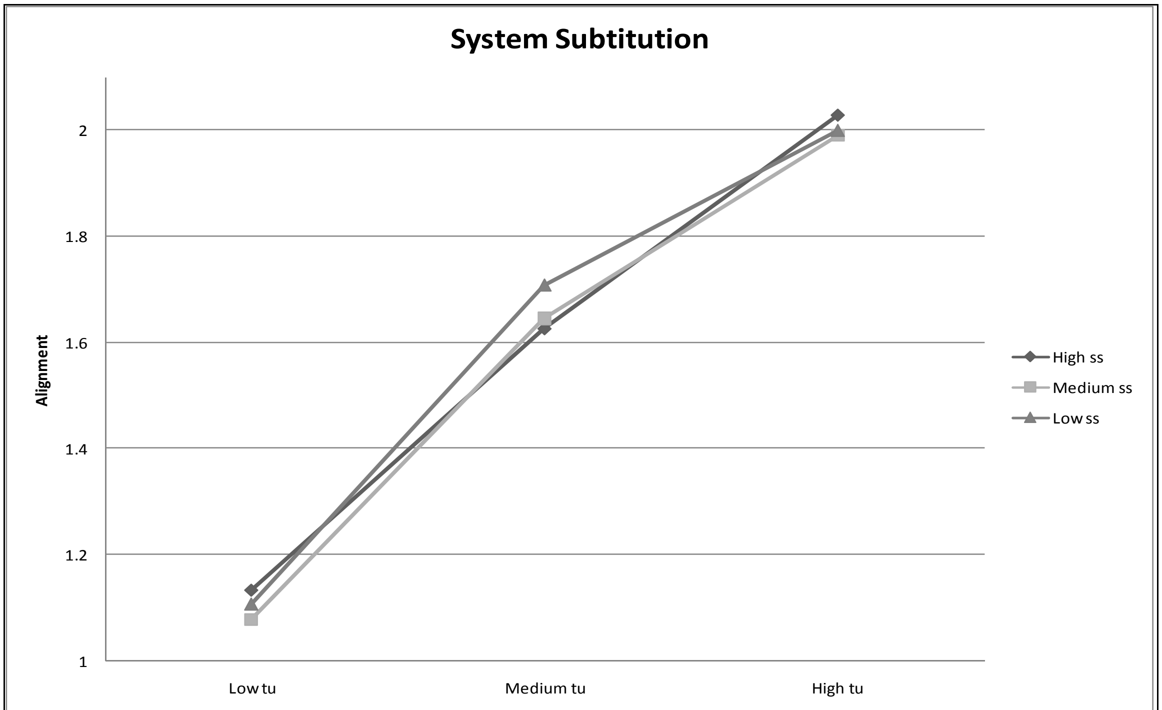

Figure 13: The Impact of Degrees of Coupling in Different Degrees of Turbulence

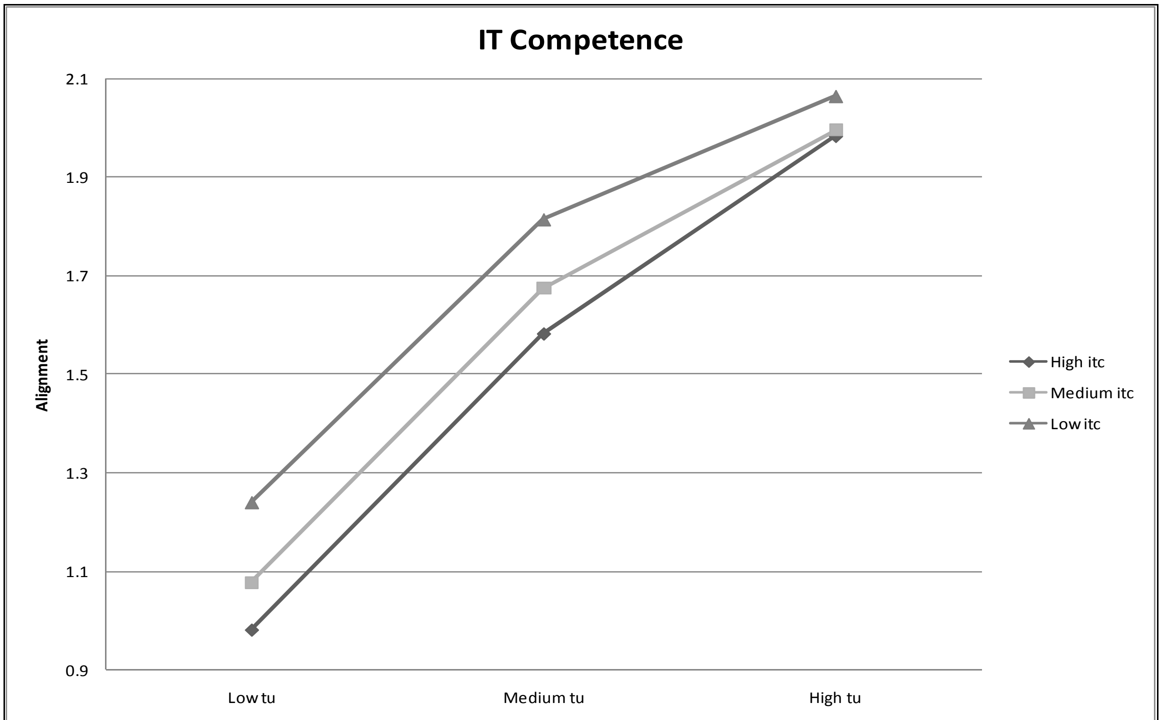

Figure 14: The Impact of Degrees of IT Competence in Different Degrees of Turbulence

Optimal Configurations

The set of experiments in investigated the effects of the idiosyncratic characteristics on the alignment of ISA in different external environments. The investigation provides insights in the optimal configurations of characteristics in different degrees of turbulence. The optimal configurations are depicted in Table 3.

A review of the optimal configurations shows that there most system characteristics have an optimal degree, regardless of the environmental turbulence. Low Coupling and high IT Competence always warrant better alignment. The impacts of Modularity and System Substitution, on the other hand, are not consistent.

The ability to exchange individual dimensions or subsystems varied with the degree of environmental turbulence. System Interoperability acts as a key driver of alignment. In an environment that is static, systems can be tweaked to efficiently align with the external conditions. However, as turbulence increases, there is a need to exchange components to efficiently adjust to the environment. In order for systems to be responsive, they cannot be tweaked by internally changing subsystems. External solutions need to be incorporated that better reflect the needs to the external environment. The interoperability of the interfaces is only a necessary condition for this effect to take place. As discussed earlier, there needs to be a market for externally components that is readily available for "on the fly integration". Recommendations of how such a market can be encouraged will be further investigated in the examination of the on demand systems in practice.

Table 3: Optimal ISA Configuration for Different Degrees of Environmental Turbulence

Parameter	**Low Turbulence**	**Medium Turbulence**	**High Turbulence**
Modularity	Medium/High	Low/Medium/High	Medium
Coupling	Low	Low	Low
System Interoperability	Low	Medium	High
System Substitution	Medium	High	Medium/High
IT Competence	High	High	High

To be certain that the separate effect hold in a setting where all characteristics are varied, a second experiment is carried out that examines the simultaneous effects of the system characteristics on the alignment with turbulent environments.

Experiment II – Simultaneous Effects

The experimental setup consists of n =100 organizations. Initially, the ISA and the idiosyncratic parameters are randomly assigned. For a given set of turbulence parameters (k =1000) alignment processes are carried out and the results of each run are recorded. This process is then repeated 1000 times with varying turbulence parameters to simulate outcomes under varying degrees of turbulence. The basic flow of the simulation is depicted in Figure 9, the simulation parameters are summarized in Table 4. The simulation was coded in R.

Table 4: Simulation Parameters for Simultaneous Experiment

Parameter	**Value**
Number of Organizations	n = 100
Number of Alignment Cycles	k = 1000
Number of Settings	g = 1000
Idiosyncratic Parameters ($itc, mo, cp, p_{si}, p_{ss}$)	Continuous within the ranges depicted in Table 1.

Data Analysis

Descriptive Statistics

The experiment yielded 100,000 observations. The seed parameters attained the expected means. IT Competence and modularity have a mean of 5 and coupling a mean of 3.[9] The probabilities representing the external resources (p_{si} and p_{ss}) and the environmental turbulence (p_t) also provide the expected means. Both the variance of differences and the variance of actual changes taking place in the external environment have considerable variation, so they can be used in further analysis. The descriptive statistics of the variables are depicted in Table 5.

Table 5: Descriptive Statistics

	Mean	Variance
Variance of Differences	1.6756	(0.4518)
Variance of Changes	8.2195	(33.8194)
IT Competence	5.0010	(6.6495)
Coupling	2.9950	(4.2101)
Modularity	5.0030	(6.6493)
System Interoperability	0.1238	(0.0106)
System Substitution	0.0245	(0.0004)
Turbulence Frequency	0.5094	(0.0835)

[9] The comparatively lower mean of coupling resulted from an adjustment of the initial distribution, where the coupling value always had to be lower than the corresponding competence value to warrant the possibility of an internal alignment process.

Regression Analysis

Three OLS regressions were performed to analyze the influence of systems characteristics, external resources, complementary capabilities and environmental turbulence on the alignment process. After the initial regressions, test for the normality assumptions were carried out. There were only low correlations between the predictors. Multicollinearity could not be detected; the variance inflation factors for all three regressions were just slightly above 1. Table 6 depicts the correlation matrix.

Table 6: Correlation Matrix

	a	*tu*	*itc*	*cp*	*mo*	p_{si}	p_{ss}
Variance of Differences	1.00						
Turbulence	0.66	1.00					
IT Competence	-0.35	0.00	1.00				
Coupling	0.22	0.00	0.25	1.00			
Modularity	-0.03	0.00	0.00	0.00	1.00		
System Interoperability	-0.01	-0.02	-0.01	0.00	0.00	1.00	
System Substitution	-0.01	0.04	0.00	0.00	0.00	0.01	1.00

Table 7: OLS Regression Results (Robust Standard Errors)

FULL	**Estimate**	**Std. Error**	**t value**	**Pr(>|t|)**	
Intercept	0.7743	0.0084	91.792	<2e-16	***
Variance of Changes	0.1507	0.0004	414.955	<2e-16	***
IT Competence	-0.1830	0.0011	-172.223	<2e-16	***
Coupling	0.1721	0.0011	159.099	<2e-16	***
Modularity	-0.0094	0.0007	-12.699	<2e-16	***
System Interoperability	-0.0310	0.0166	-1.867	0.0619	*
System Substitution	-1.7591	0.0814	-21.604	<2e-16	***
F/DF/AR^2	4.23E+04	99993	0.7173		
90%	**Estimate**	**Std. Error**	**t value**	**Pr(>|t|)**	
Intercept	3.8847	0.0176	220.61	<2e-16	***
Variance of Changes	0.0771	0.0011	69.54	<2e-16	***
IT Competence	-0.1848	0.0024	-78.15	<2e-16	***
Coupling	0.0069	0.0014	4.855	1.22E-06	***
Modularity	-0.0066	0.0014	-4.783	1.75E-06	***
System Interoperability	-0.8276	0.0352	-23.478	<2e-16	***
System Substitution	-13.7636	0.1965	-70.03	<2e-16	***
F/DF/AR^2	2787	9993	0.6257		
10%	**Estimate**	**Std. Error**	**t value**	**Pr(>|t|)**	
Intercept	0.0943	0.0021	44.884	<2e-16	***
Variance of Changes	0.1495	0.0006	256.698	<2e-16	***
IT Competence	-0.0056	0.0004	-12.879	<2e-16	***
Coupling	0.0053	0.0005	10.402	<2e-16	***
Modularity	-0.0049	0.0002	-20.264	<2e-16	***
System Interoperability	-0.0152	0.0042	-3.601	0.000319	***
System Substitution	-0.3643	0.0222	-16.434	<2e-16	***
F/DF/AR^2	1.08E+04	9993	0.8665		

Significance Levels codes: '*' 0.01, '**' 0.05, '*' 0.10, '.' 0.20**

After a visual inspection of the data plots there were signs of heteroskedasticity. The Breusch-Pagan test rejected the null hypothesis that the data is homoskedastic at the 1% level. While heteroskedasticity does not bias the estimates, there is a possibility that the variance and hence the standard errors are underestimated, leading to an inflation of t-scores and potentially making insignificant variables statistically significant. In order to remedy the effects of heteroskedasticity, the heteroskedasticity corrected covariance matrix was calculated. The calculation used White's correction as described by Long et al. (Long and Ervin 2000; White 1980). Due to the large sample size, the corrected standard errors only slightly deviated from the original regression. The regression results using the heteroskedasticity-consistent standard errors are reported in Table 7.

The regression results give insight into the simultaneous effects of the idiosyncratic characteristics on the alignment of ISA with the external environment. The regressions were carried out for the entire sample as well as for the least and most turbulent environments.

Based on the standard errors, the variance of changes of the external environment per cycle or turbulence provides the highest impact on the model fit for both the entire sample as well as for the low turbulence sample. The effect in all three regressions is positive.

IT competence has a negative effect on the variance of differences and hence a positive impact on alignment. Comparing the three regressions, the effect seems to increase as the environment becomes more turbulent. In a low turbulence environment there is only little need for adjustment, only requiring small alignment efforts. In a high turbulence environment, multiple subsystems need to be changed each cycle demanding a high IT competence to properly align the ISA attributes. The findings are consistent with the experiment that investigated the isolated effect of IT competence on alignment.

The systems characteristics show the expected effects. Coupling showed a positive effect on the variance of differences across the three regressions. The parameter is statistically significant at the 1% level. The effect was smaller in the high turbulence environment, which can be explained by the overwhelming effect of variances in realty changes on the variance of the differences between ISA attributes and the external environment in the high turbulence scenario. As with IT competence, the results are in line with the findings of the isolated experiment.

Modularity decreases the variances in alignment in all three regressions. However, compared to the other parameters, the size of the effect is small. In the regression for the entire sample, modularity is statistically significant at the 1% level. The p values for the low and high turbulence samples are also close to 0. The small nature of the estimate prompted a sensitivity analysis for the modularity parameter. The sample was further split into deciles and the p and beta values were analyzed. The analysis of the p values showed that in 8 of the cases the significance level was near or equal zero and that there were two cases were the p values were close to .05. The analysis of the estimates showed that in all but one case they took on a value smaller than zero. Yet, there was one outlier where the beta value was positive. Overall the values stayed in the range between -.01 and -.06. The analysis suggests however that the effect of modularity becomes smaller as the variance of deviations from the external environment increases. The graphs for the sensitivity analysis are depicted in Figure 6 and 7.

The small effect of modularity was predicted in the previous experiment. The simultaneous experiment provided additional evidence of the inconsistency and the size of the effect of modularity on the alignment.

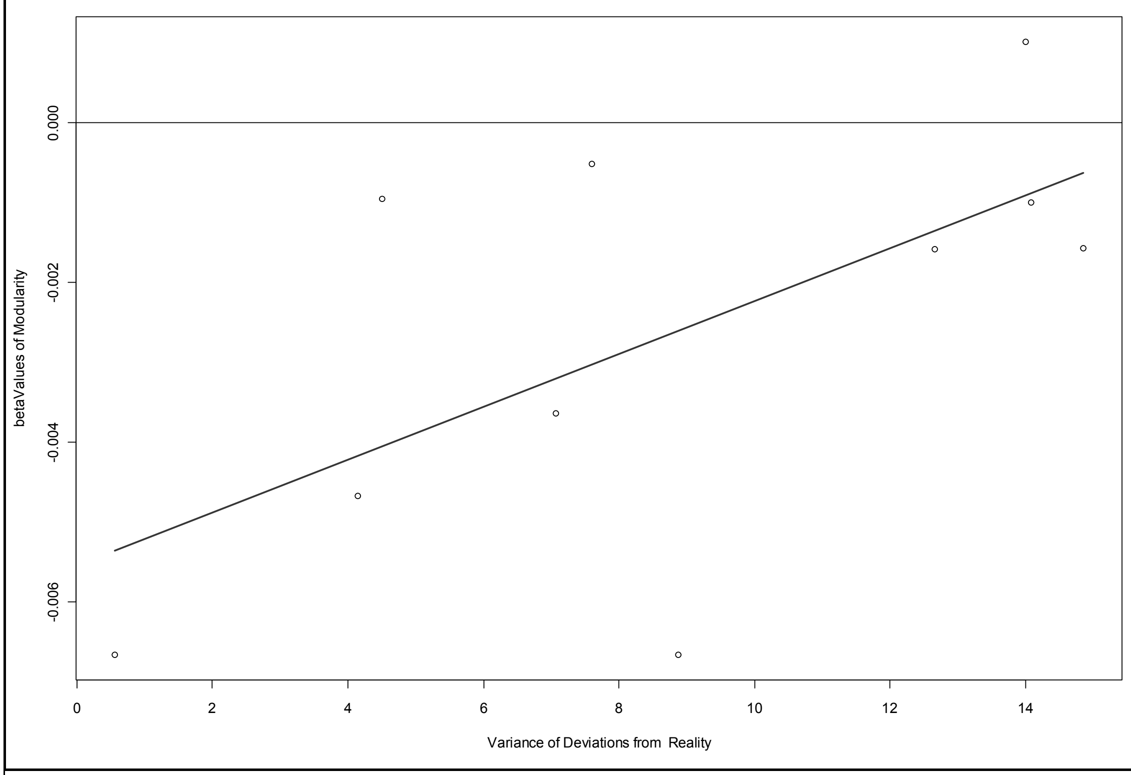

Figure 15: Sensitivity Analysis for the Modularity Parameter – P Values by Decile

Both parameters describing the interoperability with and use of external resources have statistically significant effects. System Interoperability and System Substitution decrease the misalignment of ISA and the external environment. In addition, the size of the effects increase as the environment becomes more turbulent. The effect of systems substitution is at least tenfold the size of the effect of dimension substitution. While System Substitution is statically significant at the 1% level across all three samples, System Interoperability is only statistically significant at this level in the two subsamples. In the full sample, the effect of System Interoperability is only statistically significant at the 10 % level. Overall, all parameters show the effects predicted in the theoretical model.

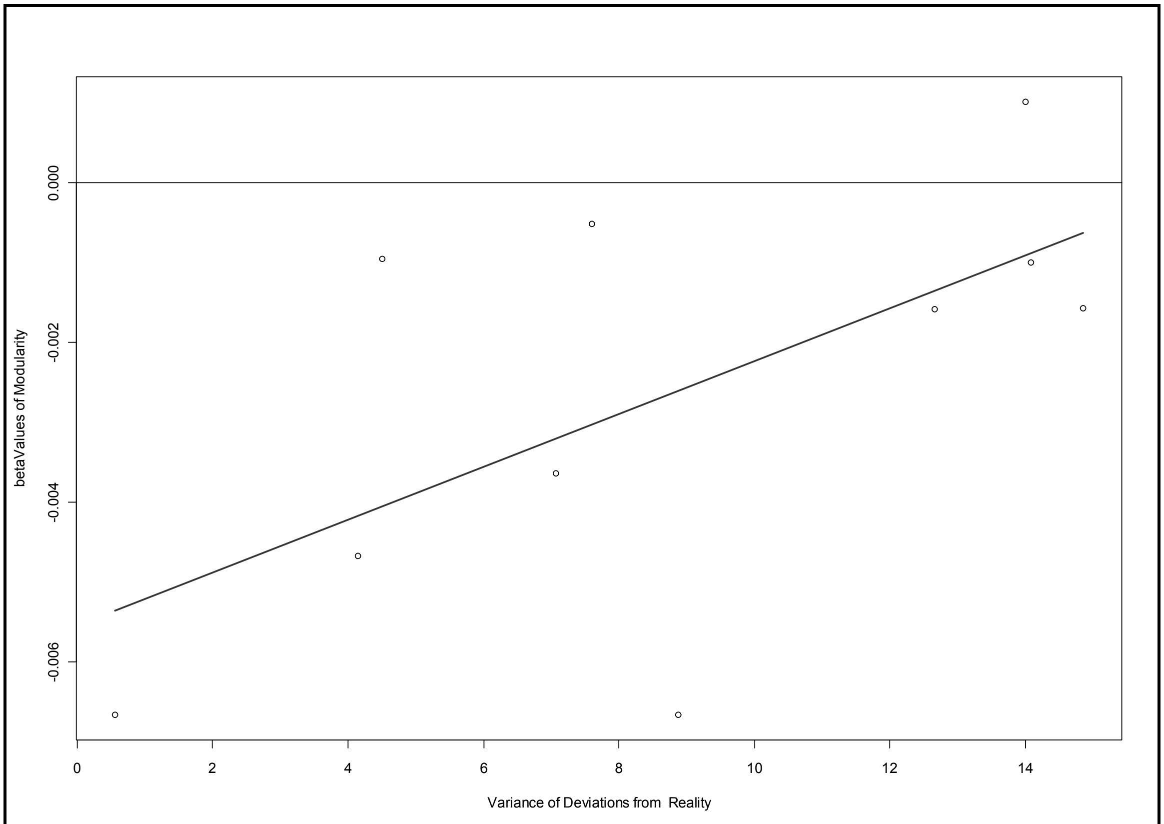

Figure 16: Sensitivity Analysis for the Modularity Parameter - Beta Values by Decile

Discussion of Limitations

As with most computational models, there are quite a few limitations in this study. First, the modeled parameters provide a simplified view of complex real world systems. While the parameters and mechanisms are derived from previous research, there are always opportunities to refine the computational model.

In that regard, the organizational characteristics have been limited to a static set of system characteristics and a single organizational capability that subsumes the idiosyncratic mix of each organization. A future extension could incorporate those idiosyncrasies at a more granular level. The model assumed that organizations are equally likely to recognize and interpret the changes and implications of turbulent environments. Moreover, organizations are a nexus of human and technological capabilities that not only adapt but also learn over time. Organizational learning and subsequent knowledge have been investigated in the context of March's (1991) model of exploration and exploitation (Kane and Alavi 2007; Prietula and Bray 2007). An inclusion of the March mechanism in future models, would better the understanding of the sensing capabilities in the context of agility.

Second, the computational model did not incorporate any market competition. While one might argue that the changing environment reflects competition, there is no interaction between agents for resources. Moreover, the external solution provision was based on the idiosyncratic interoperability probabilities. A vendor market mechanism for components or subsystems where solutions are procured would increase the granularity of the analysis.

Third, the computational model needs empirical validation to make it generalizable. IS architectures need to be analyzed and their characteristics need to be captured. This data could than be used as seeds for a future model that would simulate alignment based on actual IS architectures and related enterprise performances.

Summary

This chapter contributes to IS research in several ways. The research adds to theory building by identifying system characteristics as antecedents for alignment with turbulent environments. The application of characteristics based on service oriented design are theorized and validated as enablers of the reconfigurability of resources in the context of dynamic capabilities. As proposed by Pavlou (2006), the research further enhances the understanding of the former "black box." The main findings of the experiments are a confirmation of the proposed relationships - Information System Architectures that have service oriented system characteristics perform better in aligning with environments.

This research stream is an attempt to foreshadow the future impact of a computing paradigm that will have significant impact on both IS research and the business community. Architectures will become more service oriented. Moreover, systems will be distributed across different physical locations. In most instances, the capabilities, both hardware and software, will be owned by third parties that will lease the capabilities or simply deliver the required devices. Amazon's S3 has already started to provide leasable hardware and datacenters. On the service side, salesforce.com provides CRM services without the need to own any IT except a computer connected to the Internet. I predict the future research will move towards the effective governance and composition of on demand systems, rather than examining specific instances of the IT artifact.

CHAPTER V: INFORMATION DIFFUSION IN ON DEMAND NETWORKS

Introduction

The rise of access to and use of information and communication technologies (ICT), in particular the Internet, has spawned virtual social networks that display unique patterns of information diffusion. New forms of collaboration and knowledge transfer are exemplified through the rise of the open source software development and the increase of virtual communities of practice and online social networks. The extended reach of today's social and professional networks impacts both the diversity of the participants and the structure of the network itself. The pool of participants for a certain network is no longer restricted to a certain locale or country. This *democratization of access* has led to a global pool of potential users. Moreover, the anonymity of the Internet does not allow for discrimination of participants based on origin or educational background, leading to a *democratization of participation* and a broader, more diverse portfolio of opinions and beliefs among Internet users.

The diffusion of information between actors in social networks has been a widely studied topic in the social sciences. Examples of diffusion of information-related research are word of mouth (Brown and Reingen 1987; Dellarocas 2003; Money et al. 1998), diffusion of innovation (Abrahamson and Rosenkopf 1997; Valente 1996), knowledge diffusion in organizations (Droege and Hoobler 2003; Reagans and McEvily 2003) and dispersion of cultures (Axelrod 1997; Axtell et al. 1996). Previous research has identified actor relationships, similarity and proximity to influence the dissemination of information through social networks (Brown and Reingen 1987; Rogers 2003). More recently, the research has focused on examining "small world" networks, which more closely resemble real world communication networks (Watts 1999; Watts and Strogatz 1998). Aligning social network research closer to real world settings is one of the main motivations for this research.

The main purpose of this research is to acknowledge the changing nature of social networks caused by the increasing access to and use of ICT and to investigate the effects of network composition, size and structure on information diffusion in these virtual networks. The research does so by extending the Axelrod cultural model (ACM), an established theory rooted in political science research that examines information dissemination among actors with limited communication reach (Axelrod 1997). The extension allows an analysis of networks with more diverse actors and random structure, the two main outcomes of the democratization of access and participation. The investigation is focused on the impact of network structure parameters and gives insight on how a manipulation of those parameters can influence the diffusion of information.

Theoretical Background

In his famous work on the diffusion of innovations, Rogers (2003) showed the importance of social structures and communication networks on the diffusion of information. Rogers (2003) generalized that homophily among and communication proximity between actors in a network would increase the likelihood of the diffusion of shared ideas. Homophily in that regard should be understood as shared interests or common beliefs between actors. Communication proximity, however, refers to the directness of the communication. Thus, he proposed that an idea is better communicated directly from person to person instead of through one or multiple intermediaries. As such, if an actor wants to communicate an idea, he should talk in person to as many like-minded actors as possible to propagate it throughout a network. However, the author also recognized that these two factors decrease the chance of novel information being distributed within the communication network, since fewer actors will share novel beliefs that deviate from the homophile beliefs. Thus, novel ideas can only be communicated to a small set of actors, who themselves can have relationships with few actors that are susceptible to the novel idea.

The diffusion of innovation theory has direct implications in the context of virtual networks. First, the increasing diversity of users does not necessarily impact the behaviors and beliefs of the other users. The proverbial behavior of birds of a feather flocking together, where common beliefs are seen as a bonding mechanisms for relationships, will allow only dominant ideas or information to be shared and reinforced (McPherson et al. 2001). Conversely, novel ideas are not shared by the majority of the actors, leading to the creation of niche communities. Second, the structure of the communication networks needs to be investigated. Virtual networks allow for equal participation which is not governed by institutional structure. Thus, initially the communication structure of a virtual network is not predetermined, mirroring a random distribution of relationships (ties) between actors (nodes). A random distribution allows every node to have on average the same amount of direct ties, permitting the dissemination of novel ideas. Since real world data on the development of communication structures comparable networks at different stages of formation have been hard to collect, researchers have started to employ computational models to simulate the diffusion process.

Roger's theory was adopted by Axelrod and applied to the context of cultural expansion in the realm of political science. Axelrod (1997) was among the first researchers to employ computational modeling to analyze the spread of information. The basic premise of the ACM mirrored Rogers proposition of homophily: actors who share similar cultural attributes, which include language, beliefs attitudes and behaviors, are more likely to interact and further adapt each other's values (Axelrod, 1997). The notion of communication proximity was simplified: instead of recreating a communication structure, Axelrod equated communication proximity with geographical proximity. In his experiment, Axelrod used a spatial lattice of 100 agents with different cultural values (modeled as five digit strings) to set up the simulation. The diffusion mechanism was parsimonious: Every round an "activated" agent would donate one of its traits to one of its four immediate neighbors in the cardinal directions with a probability based on the number of their shared traits. Thus, after a successful donation, the two involved agents would share a common trait on an additional feature, making them more similar and increasing the probability of an exchange in the future.

Once agents share the same traits in all five features, they are considered a culture. The main outcome of the ACM is equilibrium where only few stable cultural regions emerge. The equilibrium is achieved when neighboring cultures do not share a common trait on any feature, preventing further exchanges. The median number of stable regions was 3. However, 14% of the runs yielded only one stable region, whereas 10% of the runs resulted in more then six regions. The original paper also suggests that the number of stable regions depends upon the range of interactions or the size of the neighborhood. Axelrod showed that the average number of stable regions increases as interactions over greater distances occur. For small neighborhoods (4 neighbors), the average number of stable regions was 3.4, whereas large neighborhoods (12 neighbors) yielded an average of 1.5 stable regions.

Axelrod theorized that his findings mirror the real world where only few cultures exist. He concluded by proposing that adoption of information based on similar beliefs leads to local convergence, but global polarity between cultures. The parsimony of the experiment and the consistency of the results sparked a stream of research that tested the generalizability of the results by incrementally lifting the restrictions of the initial model.

Several extensions of the ACM are concerned with the increase of interaction ranges and its effect on cultural heterogeneity. Shibanai et al. investigated the effect of a global mass media and modeled it as a “generalized other,” which acts as a direct (fifth) neighbor to each agent (Shibanai et al. 2001). Their experiment showed that a global agent can speed up the convergence of cultures, while at the same time yielding a smaller number of distinct cultures at the end of the simulation. Greig also investigated global impacts on the number of stable regions (Greig 2002). Similar to the original ACM, Greig increased the number of potential neighbors and ran simulations for discrete levels of neighborhood sizes. He replicated the ACM hypothesis that with increasing number of neighbors, the average number of stable regions decreases. He observed that his replication of the original model yielded an average of 4.1 unique cultures. For any bigger neighborhood size, the number of cultures dropped below 1.5. Most of his runs yielded quasi-homogeneity with an average of 99.15% of the population belonging to the dominant culture. Ward (2006) introduced the concept of virtual neighbors to the ACM model. Her model showed that an increase in access to global communication and thus to virtual neighbors, decreases the number of unique cultures over time (Ward 2006). The most recent extension of the ACM deals with the impact of temporal changes in the network structure. Centola et al. (2007) found that random coevolving changes in both the actors attributes and in the ties between them can influence the outcomes of the ACM (Centola et al. 2007). They found that dynamic network structures still lead to disconnected cultural regions.

Two general effects of the system parameter changes can be generalized from the ACM research stream: a) In locally restricted communication networks, an increase of communication range leads to fewer distinct cultures, and b) Initial local similarity leads to a higher number of distinct cultures in the system. In other terms, similarity leads to diversity through the creation of boundaries, while range influences the size of the distinct territories. Hence, in a network where only the parameters of geographic proximity are varied, the general outcome of local convergence and global polarization still holds true; only the extent of the outcome changes.

A more recent research stream deals with the influence of network topologies on computational models. Watts et al. (1998) have shown that there are three types of network topologies that will influence the results of information diffusion (random, fixed, "small world"). They argued that random networks built according to the Erdos–Renyi model, usually have a very small average path length between actors and a low clustering among nodes. Watts et al. argued that high clustering is inherent in most real world networks and thus needed to be incorporated in network topologies. Their model became know as "small world" networks. The underlying lattice structure in the ACM produces a locally clustered network. However, the lack of random links between actors increases the average path length which deviates from the "small world" model. Thus, the original ACM presents a network structure that lies between the "small world" properties described by Watts et al. (1998) and the random graph properties described by Erdos et al. (Erdos and Renyi 1959).

Staying true to Rogers' (2003) theory and the recent research on network topology, the structure in communication networks needs to be examined. Thus, to operationalize the construct of Rogers' theory and to better approximate the "small world" properties of today's virtual networks, the geographic restrictions on the ACM need to be lifted. An analysis based on network level parameters will allow for a better understanding of the information diffusion process in virtual networks.

Theoretical Model

The setup of the ACM on a grid, where communication proximity equals geographical proximity, leads to the diffusion and eventual dominance of a few shared cultures rather than to a system of many diverse and novel cultures. From a network perspective, the spatial grid is an extreme network structure. The research model investigates the impact of the network structure parameters and of the main process variable, average convergence velocity (V), on the final number of cultures.[10].

The Impact of Structural Parameters

This section will summarize four network structure parameters which in the original model can be considered extreme, and how a variation of those parameters impact the diffusion of information. The network parameters are summarized in Figure 17.

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[10] The previous research has simultaneously analyzed the number of final cultures and the size distribution for the remaining cultures. The previous results show that the dominant culture at least contained 85% of the actors. For comparison purposes, the size distributions for the experiments are listed in the descriptive summary of the results (Table 3). Yet, the inclusion of an additional outcome in the hypotheses is outside of the scope of this paper

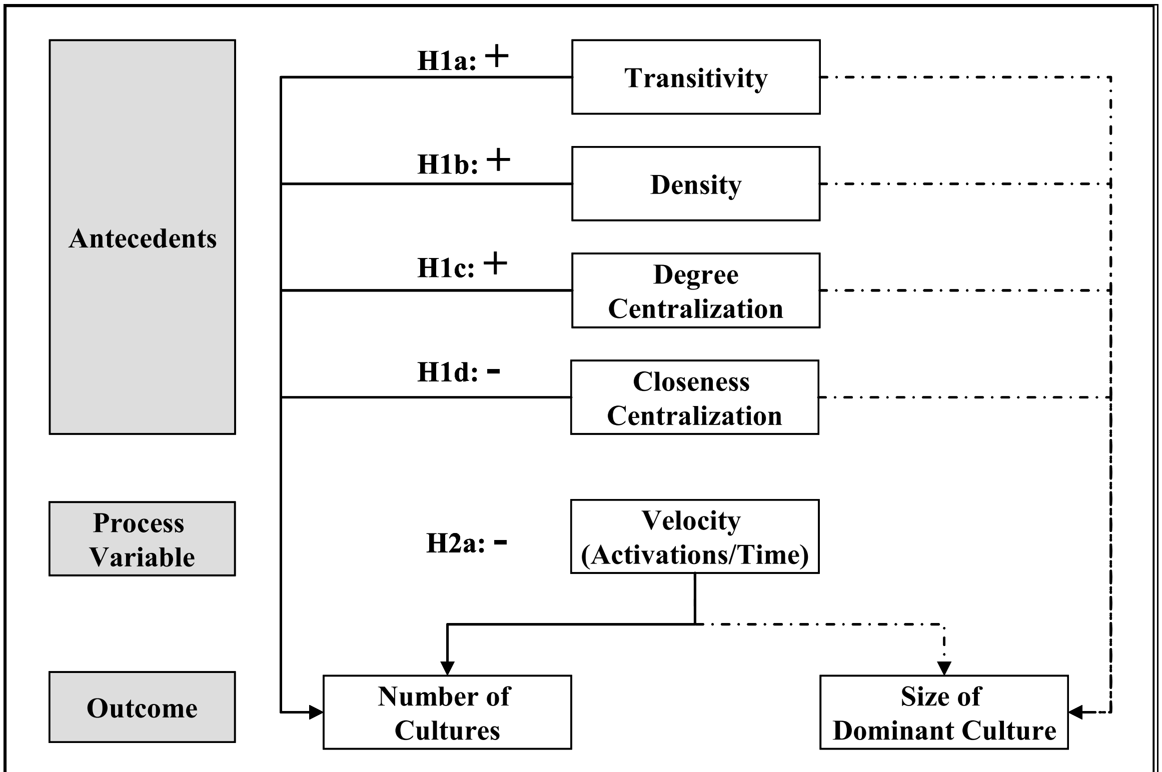

Figure 17: Research Model – Influence of Structure Parameters and Process Variable on the Outcome of the ACM

Transitivity

Transitivity (T) is defined as the proportion of node triplets in a network that have three direct ties (Wasserman and Faust 1999). High transitivity indicates a high degree of reciprocity. For example, if three nodes have ties with each other, information can freely flow between the actors using direct communication. Since all nodes are connected, the triplet is considered transitive. However, if there are only ties between nodes A and B (AB) and nodes B and C (BC), no direct communication can take place between nodes A and C. Intransitive triplets result in low network transitivity. The original ACM has transitivity of 0 and thus an abundance of intransitive triplets.

Granovetter (1973) demonstrated that weak ties between different personal networks can enable the diffusion of unique information. Rogers (2003) suggested that an imbalanced distribution of communication ties within the network can lead to the emergence of more novel ideas. Rogers recognized that the emergence of the Internet increased the availability of personal networks with weak ties (Rogers 2003; Rosen 2000). A transitivity of 0 will not be achieved in virtual networks, because it is unlikely in a large network that two actors do not have independent relationships with third actor. As such, the ACM model, which only consists of intransitive triplets, skews the outcomes of the simulation. In particular, recalling the basic exchange mechanism of the ACM, communication between actors is less efficient because information cannot directly be communicated from one particular agent to another, unless the agents are direct neighbors. The low transitivity score in the ACM yields more exchanges of traits (activations) before the system converges in a quasi-homogenous state. Therefore, the low transitivity skews the number of activations compared to a real world virtual network with at least some transitive triplets. Transitive networks should yield more attribute exchanges. An increase in activations should mean that there is a slower manifestation of regional boundaries since the influence of individual actors is more balanced, allowing minority cultures to survive.

Hypothesis 1a: The transitivity of the network has a positive impact on the total number of cultures.

Density

Network density (D) describes a network as a ratio of actual ties within the system over the maximum potential connections in the systems. Wasserman and Faust (1999, p. 182) argue that density by itself does not sufficiently describe the centralization of a network. However, it can provide useful information about the network structures as long as it is used in conjunction with the centralization measures presented below. A density of 1 indicates that each actor has a direct tie to each other actor within the system. A high density should foster the exchange of information since actors are connected to more peers and thus have a more equal individual influence on the outcome of the exchanges. Being connected should increase the chances of exchanges and should allow minority cultures to emerge. As such more but smaller regions should emerge in the quasi homogenous state.

Hypothesis 1b: Density of the network has a positive impact on the time of total number of cultures.

Group Degree Centralization

Degree centrality ($C_C(n_i)$) describes the composition of the ties within a network. In particular, it compares the distribution of ties around nodes within a system (Wasserman & Faust 1999). The standardized index of all actor degree centralities, degree centralization (C_D), quantifies the variability of actor degree centralities. If, for example, one actor has ties to all other actors, while the other actors do not share connections among themselves, the centralization of the network is 1. On the contrary, if actors share the same amount of ties, centralization is 0. Social network analysis literature shows that degree centralization is a good predictor of overall efficiency of information flow (Cook et al. 1983). High network centralization suggests that information is better broadcast through well-connected agents that act as information hubs and key influencers.

In the original model, the degree centralization is 0. It seems unlikely that in a large virtual network each member has direct contact with exactly the same amount of peers. On the contrary, popular members or moderators in the network have more connections than the average member. As such, the impact of degree centralization is underemphasized in the original model. In the original model, agents are less active in disseminating information compared to a virtual network with high degree centralization. High degree centralization thus can be equated with higher influence of individual actors upon adjacent peers. High degree centralization indicates a small number of better connected actors. The actors can influence their less connected peers, quickly creating distinct cultural regions. They will compete with the few other well connected actors that will follow the same process. Thus, more but smaller culture regions should emerge based on high degree centralization.

Hypothesis 1c: Degree centralization of the network has a positive impact on the total number of cultures.

Group Closeness Centralization

Watts et al. (1998) argued that average path length is a structural parameter that influences both the topology of the network and the related information diffusion process. Path length describes the shortest number of ties or geodesic distance between two actors in a network. Wasserman and Faust (1999) argue that shorter path lengths decrease the influence of individual actors. They argue that shorter path lengths enable linkages between actors that can bypass influencing actors with a high number of connections. Closeness centrality ($C_C(n_i)$) captures the notion of shortest path length. The measure is calculated as the inverse sum of geodesic distances of actor *i* to all other actors. At the maximum, closeness centrality reaches 1 when an actor is adjacent to all actors and comes close to zero when only few actors can be reached. Group closeness centralization (C_C) is the standardized index of all closeness centralities, reaching the same limits. Closeness centralization in the original model is 0, since all the geodesics are equal. Real world networks are less evenly distributed. The path length varies between actors (Watts 1998), resulting in higher closeness centralities. High closeneness centralization hints at some actors having shorter path lengths than other, leading to greater influence in the network. Greater influence will result in larger regions, thus decreasing the number of final outcomes.

Hypothesis 1d: Closeness centralization of the network has a negative impact on the total number of cultures.

The first set of hypotheses is distinct from previous research by relating the measures of the network structure to the process variables of the simulation: time to conversion and activations until convergence. In the next section, I will propose a hypothesis that relates the process measures to the final outcomes of the simulation.

The Impact of Convergence Velocity

The prior research has not investigated the impact of process variables on the outcomes of the ACM. Aside from the exchange mechanism, little effort has been undertaken to investigate the convergence process. Research in different fields has started to open this “black box" by investigating intermediate and process variables. Laguna et al. used a process parameter to model the rate of exchange between agents to predict final outcomes (Laguna et al. 2003). In the context of this network analysis, convergence velocity is the ratio of total number of agent activations over time of convergence. Those measures can also be captured in the ACM. Since the ACM is an ultimately converging system, the velocity of convergence can be assumed as a measure of the effectiveness of the information flow and exchange. In a sense, velocity of convergence captures favorable conditions for the convergence that lay outside of the idiosyncrasies of a-priori measurable network parameters or the particularities of the exchange mechanism. Thus, by measuring the process, the distribution of cultures can be predicted before the outcome occurs.

Hypothesis 2: The velocity of convergence will have a negative impact on the number of distinct cultures in the converged state.

The Impact of Network Type

In the early research studies, the basic lattice structure underlying the ACM was used as the standard network typology (Axelrod 1997, Greig 2002) and only few of the network parameters were varied. Even when network density was increased by extending the range of interaction, leading to fewer distinct cultures in the converged systems, the parameters were not included in the analysis of the results. Centola et al. (2007) were the first ACM researchers that acknowledged the influence of network topology on the exchange process. However, instead of *a-priori* setting different network structures, they analyzed the impact of the introduced cultural drift on resulting network topologies. Thus, Watt's (1999) notion that different types of network topologies impact the results of information diffusion has so far been neglected in the ACM research. The original ACM is not quite a "small world" network, since the average path length is rather large. Thus, an introduction of a "small world" network structure and a random network structure will be employed to test Watt's argument in the context of the ACM.

Hypothesis 3: The underlying type of network typology will moderate the outcome of the ACM.

Table 8: Definition of Independent Variables

Variable	Definition	Interpretation	Equation
Group Degree Centralization Index	Group level index based on the number of links incident upon a node	Measure of activity within a network	$C_D = \frac{\sum_{i=1}^{g}[C_D(n^*) - C_D(n_i)]}{max\sum_{i=1}^{g}[C_D(n^*) - C_D(n_i)]}$
Group Closeness Centralization Index	Group Level index based on the shortest path length of a node	Measure adaptability to changes	$C_C = \frac{\sum_{i=1}^{g}[C'c(n^*) - C'c(n_i)]}{max\sum_{i=1}^{g}[C'c(n^*) - C'c(n_i)]}$
Group Graph Density Index	Index of the ratios of actual ties present and the maximum ties possible	Measure of cohesiveness of a network	$D = \frac{\sum_{i=1}^{g}[C'_D(n_i)]}{g}$
Group Transitivity (weak ties)	Proportion of node triplets that have less three direct ties	Measure of information bridges	$T = \frac{\sum_{i=1}^{g}[tw_i]}{\max\sum_{i=1}^{g}[tw_i + ts_i]}$
Velocity	Ratio of activations and time per convergence	Speed of system convergence	$V = \frac{Activations}{Time}$

Research Design

The original ACM consisted of 100 agents, with 5 features, each having one of 10 traits. An agent's culture is described as a 5 digit string (i.e. 4, 3, 5, 9, 1). Axelrod used a geographical distribution of the agents on a 10-by-10 lattice structure. One of the premises of the theoretical model was that the reach of communication is limited. This condition was implemented in the computational model by allowing agents to only interact with their immediate neighbors in the cardinal directions (up to four). The basic algorithm, adopted from Centola et al. (2007), is described as:

1. Select an agent *i* at random from the population. Call *i* the donor agent. From among *i*'s neighbors, select a random neighbor *j* and call this agent the receiver.

2. Calculate the cultural similarity between *i* and *j* as the number of features on which *i* and *j* have the same trait: $O(i,j) = \sum_{f=1}^{F} \partial\sigma_{if}, \partial\sigma_{jf}$.

3. If *i* and *j* share some features in common but are not identical *(O< O(i,j)<F),* then interact with the probability *O(i,j)/F.*

4. Agent *i* interacts with agent *j* by choosing a random feature g such that *i* and *j* do not already overlap ($\sigma_{ig} \neq \sigma_{jg}$). The receiver *j* then sets its trait as a feature g to match its donor's trait as feature g $(\sigma_{ig} = \sigma_{jg})$.

Once an agent pair is chosen to communicate with each other, the probability of adopting a new common trait for a feature is based on the number of already shared traits. If a pair shares 3 traits, the probability of exchanging a common trait for an additional feature is 60% (3 shared features divided by 5 total features). If no feature is shared, no exchange occurs. As a result, exchanges take place until all agents either share all or no traits. When equilibrium is reached, the average number of cultural regions is recorded.

Experiments

Overall three experiments were carried out to test the research model. The goal of the progression was to lift the constraints imposed by the original lattice structure and to approximate the network types suggested by Watt's (1999). First, a replication of the original ACM was carried out to validate the simulation as described in the research design.

The first extension followed the original model with the exception that rather than being connected by geographic proximity, agents are part of an imposed network structure. The structure is generated using a fixed coefficient (.0404) for the network density (which equals the network density in the original model) and is operationalized in a 100x100 sociomatrix with 1 signaling a nondirectional tie and 0 signaling a lack there of. As with the original ACM, the exchange of traits occurs when at least one trait is the same. However, the second condition for an interaction is a tie as defined by the network structure. A nondirectional tie has to exist in order to fulfill this second condition. The extension shortened the average path length of the network and thus is a close approximation of a "small world" network.

The second extension removed the " "small world" constraints. Network densities were seeded randomly, ranging from .005 to .995. The only condition for the network structure was that all actors are connected in one network. The condition was imposed to both warrant the validity of the network measures and to prevent isolated actors from directly increasing the number of final cultures.

For all three experiments, 100 runs with different initial network structures and traits are carried out. For all activation cycles the changes in traits and number of cultures as well as the relevant network and process measures were recorded.

Data Analysis

All three experiments converged and provided final outcomes. The mean values for the structure parameter are within the expected ranges. Yet, the variances for the structure parameters are very small. This effect was not expected and points to Wasserman et al.'s (1999) notion of always interpreting network parameters both in terms of their means and their variance. The small variances will be further discussed in the data analysis section.

In terms of the final number of cultures, the replication and the original ACM yielded similar results. The average number of cultures was (3.45) was slightly higher than the original model (3). The percentage of heterogeneous systems with more than six cultures (11%) was also marginally higher than in the original ACM (10%). The number of systems with homogenous cultures was slightly lower (12% vs. 14%). Overall, the results were similar enough to validate the simulation. Table 9 summarizes the descriptive statistics for both the base experiment and the extension experiments.

Table 9: Means of Variables (Variance in Parentheses)

	Original ACM		Base		Extension I		Extension II	
Density	0.0040	(0.00)	0.0040	(0.00)	0.0415	(0.0000)	0.5009	(0.0707)
Transitivity	0.00	(0.00)	0.00	(0.00)	0.0402	(0.0001)	0.4992	(0.0707)
Degree Central.	0.00	(0.00)	0.00	(0.00)	0.0594	(0.0001)	0.1055	(0.0009)
Close. Central.	0.00	(0.00)	0.00	(0.00)	0.0727	(0.0006)	0.0593	(0.0002)
Activations	-	(-)	13779	(2.4.E+07)	10313	(1.4E+07)	14834	(1.2 E+07)
Time	-	(-)	591.10	(29468)	386.50	(10930)	319.20	(10097)
Velocity	-	(-)	23.68	(42.61)	26.83	(46.41)	47.63	(62.62)
# of Cultures	3.20	(-)	3.45	(4.13)	4.41	(6.37)	1.62	(0.54)

The outcomes of the extension were also in line with the results of previous research. The first extension yielded an average number of cultures of 4.41 with an average size of 87.33 for the dominant culture. The second extension provided an average of final cultures of 1.62 and an average size of 98.00 for the dominant culture.

Table 10: Distributions of Number and Size of Cultures

Distribution	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**>9**
Base	12	33	14	13	13	4	7	2	1	1
Extension I	9	15	20	14	14	10	5	3	6	1
Extension II	50	40	9	1						
Sizes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**>9**
Base	87.23	8.52	2.75	0.76	0.40	0.16	0.11	0.04	0.02	0.01
Extension I	87.33	7.99	2.36	1.00	0.56	0.28	0.18	0.13	0.10	0.04
Extension II	98.00	1.83	0.15	0.01						

Overall four different OLS regressions were carried out. For each extension, the influence of the structural parameters on convergence velocity and number of final cultures was tested. The regressions on velocity solely served the purpose of testing the independence of structural parameters and the process variable. Both models show a poor fit with an adjusted R^2 of .06 and .05 respectively. However, in the first extension density is statistically significant at the .1 % level. Yet, the lack of variance of density in the first model points towards a spurious result rather than to a statistically meaningful relationship. The regression on velocity in the second extension shows a statistically significant relationship with degree centralization at the 5% level. It suggests that degree centralization is positively related to convergence velocity. Given the poor fit of the model this relationship also has to be interpreted with caution. Overall there does not seem to be a statistically significant impact in either of the models.

Table 11: Regression Results

Velocity	**Extension I**			**Extension II**		
	Estimate (Std. Error)		Pr(>|t|)	Estimate (Std. Error)		Pr(>|t|)
Intercept	0.25 (9.95)		0.980	41.19 (3.90)***		0.000
Density	731.67 (240.91)***		0.003	316.97 (231.44).		0.174
Transitivity	-42.14 (58.68)		0.474	-308.62 (231.22).		0.185
Degree Centralization	-2.38 (63.92)		0.970	62.64 (30.13)**		0.040
Closeness Centralization	-26.98 (28.92)		0.353	-73.90 (57.77).		0.199
Adjusted R^2/DF/F	0.060	95	2.582	0.052	95	2.366

Cultures	**Extension I**			**Extension II**		
	Estimate (Std. Error)		Pr(>|t|)	Estimate (Std. Error)		Pr(>|t|)
Intercept	14.36 (2.85) ***		0.000	2.77 (0.51) ***		0.000
Density	-61.84 (72.16)		0.393	68.25 (20.67)***		0.001
Transitivity	23.22 (16.83) **.**		0.171	68.12 (20.65)***		0.001
Degree Centralization	28.12 (18.28) **.**		0.127	4.43 (2.73) **.**		0.108
Closeness Centralization	-26.12 (8.31) ***		0.002	-2.68 (5.15)		0.604
Velocity	-0.232 (0.03) ***		0.000	-0.03 (0.01) ***		0.001
Adjusted R^2/DF/F	0.439	94	16.53	0.141	94	4.266

Significance Levels codes: '*' 0.01, '**' 0.05, '*' 0.10, '.' 0.20**

Extension I – Quasi "Small World" Model

Extension 1 introduces variation to the structure perimeters. It simulates network structures that are randomly assigned but that are seeded around the original model's network density of .0404. By abandoning the lattice structure while keeping similar densities, the average path length is shortened and clusters are created. This quasi –"small network" setup provides insights into the impact of network structure on the outcome of the ACM mechanism. The regression analysis provides partial support for the proposed hypotheses. With the exception of network density, all coefficients for the independent variables have the predicted impact on the final number of cultures. Yet, only closeness centralization and convergence velocity are significant at the 1% level. Transitivity and degree centralization are statistically significant at the 20% level, which is below the standard cutoff point for regression analysis. The lack of variance for the two variables might explain why the impact cannot be predicted with more statistical confidence. Overall, the model has good fit with and adjusted R^2 of .44, providing a reasonable support for the theoretical model.

Extension II – Random Network

The second extension investigates the behavior of the ACM in a random network setting. As with the first extension, all dependent variables have the predicted impact. However, convergence velocity is the only independent variable that remains statically significant at the 1% level. With the considerable higher variances in this model, both transitivity and density are statistically significant at the 1% level. Degree centralization remains slightly above the 10% significance level, while closeness centrality is not statistically significant in this model. The overall model only has a small adjusted R^2 of .14, indicating a lesser fit of the theory for random network settings.

Discussion of Results

There is partial support for the hypotheses and the overall theoretical model. Hypothesis 1a proposing that transitivity has a positive impact on the total number of cultures is supported. Transitive triplets balance the influence of individual actors. Thus, more actors exchange more attributes. An increase in activations results in a slower manifestation of regional boundaries, allowing minority cultures to survive.

Hypothesis 1b proposed a positive impact of network density on the final number of cultures. The hypothesis was only supported in the context of the random network setting. Wasserman et al. (1999) suggested that density should only be considered along with the other structure parameters in determining its impact on actor behavior. In the random network experiment, density and transitivity were highly correlated, suggesting that after a certain threshold, both seem to be capturing the same effect. However, density might still influence the ACM in a "small world" setting. It was pointed out earlier that density impacted convergence velocity in the preliminary regression analysis. Thus, the effect of density in the "small world" model could have been subsumed by the effect of convergence velocity on the final number of cultures.

The negative impact of degree centralization on the number of cultures was proposed in hypothesis 1c. While the direction of the impact did hold true , in neither of the two extension experiments was this relationship supported at the 10% significance level. The imbalance of actor degree centralities does not seem to impact the ACM outcomes.

The final structural parameter hypothesis concerned the impact of degree centralization. It was assumed that high degree centralization would capture the negative effect of shorter geodesics on the final number of cultures in the ACM. The relationship was supported in the “ “small world” setting. However, in the random network experiment where closeness centralization became smaller (both in terms of mean and variance), no statistically significant impact could be measured. Again there seems to be a threshold value for which closeness centralization has an influence on the ACM.

Hypothesis 2 stated that convergence velocity would negatively impact the number of final cultures in the ACM. The relationship was statistically significant in both network settings. Convergence velocity can be considered a variable that measures the effectiveness of the overall information diffusion in a network in the context of the ACM. The finding shed new light on the traditional model of simply analyzing the relationships between antecedents and outcomes. Complex processes involve simultaneous effects that can not always be measured directly. By investigating process variables, those idiosyncrasies can be better approximated. In addition, convergence velocity could be used as a predictor of the final outcome, during the experiments, potentially reducing the time and effort to run simulations until they converge. Lastly, convergence velocity is only an average. Derivates such as acceleration or current velocity might provide even more insightful variables that can better explain the ACM process.

The last hypothesis stated that the network types influences the outcome of the ACM. The two extensions provided different results in terms of extent and variance of the dependent and independent variables as well as the relationship between the two. In the "small world" model, the centralization indices measuring imbalance in the distribution of ties and nodes seemed to have a greater influence on the final outcomes. In the random network setting, the structural parameters measuring averages (density & transitivity), were statistically significant. While those results cannot be generalized, it certainly provides interesting starting points for further examining the applicability of structural parameter measures in different network types.

Discussion of Limitations

This research provides interesting insights into the influence of structural parameters and process variables on the outcome of the ACM. As with abstraction, the experiments include assumptions and simplifications that do not correspond with real world networks. The most severe assumption is a static network structure that has permanent ties between actors, where actors are equally susceptible to both receiving and disseminating information. Recent research has started to provide more differentiated models of social networks, based both on empirical data and by using computational models (Centola et al. 2007; Kane and Alavi 2008; Kossinets and Watts 2006) Moreover, in this research model actors cannot learn or innovate by themselves subject to external influences in order to change. Different aspects of self innovation and susceptibility have been studied (Abrahamson and Rosenkopf 1997; Centola et al. 2007; Weitzel et al. 2006), but a comprehensive model that captures <u>all</u> aspects of a human social network has yet to emerge.

Summary

This research examines network parameters and process variables that influence the ACM and to provide a theoretical model that explains the impact of said variables on information diffusion in virtual networks. The research confirmed the main outcome of the ACM that similarity and communication proximity based information exchange lead to local convergence and global polarization of information. But it also showed that network structure parameters, process variables and network topology type mediate the extent of the expected heterogeneity of information based outcomes.

The most interesting result of this research is the role and influence of convergence velocity. Velocity has a negative influence on the number of final cultures in the ACM. This impact is independent of the network parameters and the type of network. Convergence velocity captures network inherent idiosyncrasies that cannot be measured through process antecedents. It reveals insights over how well a particular network is set up to process and disseminate information. As such it can be used during a diffusion process to measure the current performance and to predict the final outcome of a converging process.

The findings are applicable to a variety of ICT enabled processes. One prominent example is software development by distributed developers in an open source project. By analyzing the current network structure and by recording the frequency of messages exchange in the associated forums, one could start to predict not only when but also if a new update will be released. In a similar vein, competing efforts in trying to develop and establish a new standard or network protocol could be evaluated and the possibility of a final compromise could be evaluated based on the network structure of the parties involved and the rate of communication that takes place.

The findings of the research provide a validation of Roger's initial theory of information diffusion in the context of virtual networks: As long as users connect to each other and have something in common, information can diffuse through networks. Ultimately, the democratization of access also leads to a democratization of information, which is exemplified through collaborative efforts such as Wikipedia or the open text project. However, while ideas of the majority will be shared, the attention should focus on how effectively those minority opinions or as Rogers calls them, novel ideas, are communicated. In that regard, there is a need to design virtual social networks so novel ideas can also be promoted. By effectively manipulating the network structure parameters and process variables, novel ideas can be propagated faster to a broader audience.

Increasing access to and use of ICTs presents both a great opportunity and tremendous challenge for Information Systems research. The exponential growth and availability of data fueled by ICTs requires new research methods that go beyond the simplistic cause and effect models. There is an increasing interest in studying the complexities of social network mechanisms in IS and management and marketing research. Recently, Social Network Analysis has been used to analyze IS proficiency in organizational units and information seeking, and knowledge management (Borgatti and Cross 2003; Kane and Alavi 2007; Kane and Alavi 2008). As most networks are enabled by IT artifacts, SNA will become of every increasing importance to IS research.

Developing computational models that can validate findings and test the impact of parameters will become an integral part of future research.

With the emergence and growth of social networks, it was important to incorporate an examination of the *on demand* principles in the realm of social media and community capabilities. Hence the examination of communication patterns in social networks and how the evolution of control and operations of on demand impact the communication process. The increase in the democratization of access and the democratization of participation has a significant impact on the patterns of interchange. These patterns may be enhanced, or diminished via the mechanisms of on demand architectures. The study examined information diffusion changes with increasingly diverse and dispersed user populations. The study extended Axelrod's cultural model (ACM). The study employed a computational model to investigate the effects of changing network structure parameters. The on demand environmental elements suggest a good alignment of the social networking patterns and the easy scaling of the on demand mechanisms.

CHAPTER VI: ON DEMAND SYSTEMS IN PRACTICE

Introduction

In the previous chapters we have identified several dimensions of on demand principles. In order to facilitate on demand services, a technological architecture has to be in place that allows for interoperability, modularity and loose coupling. To take advantage of the architecture, several environmental conditions need to be fulfilled.

First, there need to be complementary services that can be coupled with the architecture platform. If services are unavailable, the architecture remains closed and does not become an on demand system that can adapt to changes in the environment. If services indeed are available, it would be advantageous if there is competition between the service providers, because market competition would facilitate innovation and hence continuous improvement to the services provided. Second, the external services need to be composed in a sensible manner. Even if the architecture allows for technological interoperability with external services, there needs to be an economic reasoning behind the composition. The integrated services have to create digital options that match the needs of the market. In an ideal scenario, services are automatically matched to the needs of the environment and disposed of if no longer needed. In the short term however, the matching will still require intelligent business decisions. Hence the composition competence will require a considerable amount of business acumen until intelligent systems evolve. Third, the composed on demand system needs to be able to match the complexity and turbulence technological and business environment. The analysis of the computational model suggests that the level interoperability needs to match the level of turbulence. In some cases, the environment might only change slowly. In such a scenario, there might not be a need for an interoperable on demand system but rather an old fashioned, hardwired system that efficiently computes known routines that have been optimized towards a static environment. The dimensions of on demand system success are depicted in Figure 18.

For the purpose of examination of the effective or ineffective leverage of the principles of on demand environments, we next look at three radically different domains – one a peer-to-peer service environment, one a commercial environment where the adoption for internal application of a new technology is met by the challenge of client valuation and a third environment where complex, autonomous agents mix human and machine resources in a continuous exchange to sensing and responding. Each domain presents interesting challenges of intra-organizational and inter-organizational leverage of new platform technologies. The cases are common in that each involves the employment of a new IT architecture into an existing operating theater. New technologies and on demand principles guide the evolution of old forms into new operating practice. Not all the initiatives are a success, and lessons are learned as we witness the effective, or ineffective, employment of the on demand principles. The cases present an assessment of the social justification, the conceptual justification and explanatory strength of on demand principles applied to the distinct domains.

The three case studies exemplify different incarnations of on demand systems both the enterprise and the military realm. The profiles of the case scenarios showcase the characteristics of each information system and consider the role of on demand systems in changing the strategic options for the entities that have deployed those principles.

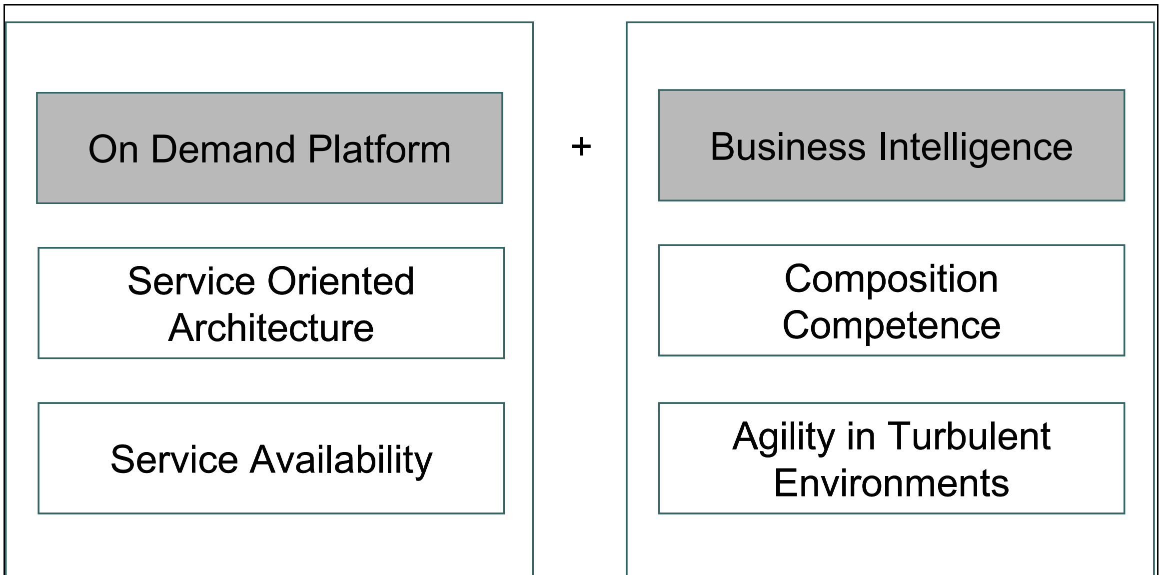

Figure 18: Dimensions of On Demand System Success

The first case study looks at Skype SA, which through the development of a distributed peer to peer system, has radically changed the telecommunications market and presented an opportunity for an acquirer to transform their business – buyer-seller relationships. By deploying a distributed information systems, Skype has created a virtual telecommunications network - one that benefits from network externalities and a low cost of ownership, leading to a tremendous cost advantage that made the company the largest provider of international calling services worldwide

The second case study concerns the logistics provider CHEP. CHEP is an innovator in creating a distributed information system that gathered information mainly from, and about, its assets that are field deployed. However, since CHEP built a new physical infrastructure and used an emerging technology (RFID) that did not have mature open standards, the undertaking was not a commercial success. Waiting for the client community to see the value and therefore increase their “willingness to pay” the company only partially implemented their planned on demand environment. The case exemplifies that building a distributed platform can only be successful if it enables the incorporation of services that can create value from the information gathered by the distributed information systems infrastructure.

The third case study traces the deployment and use of unmanned systems (UMS) in the US military. UMS promised to decrease the reliance on and the endangerment of soldiers in gathering information in a constant conflict zone. The pressing need to engage technology to serve the dull, dirty and dangerous tasks of the military, the Department of Defense seeks to leverage unmanned systems. Due to large investment by the Department of Defense, a broad variety of UMS with different capabilities have been developed by defense contractors. While the individual systems had superior sensing capabilities, there were issues with combining and processing the data from different systems to create a holistic picture of the intelligence gathered. The key inhibitor of creating a distributed system that could provide on demand information from a system of systems was the inability of the military to create and enforce open standards that would have allowed for sharing and analyzing data. On demand principles that govern the complex interaction of machine and man in complicated and information rich environments are essential to implement services like “publish and subscribe”.

The chapter concludes by summarizing the lessons learned from the three case studies by highlighting the importance of following the on demand principles in creating and leveraging distributed systems.

Case Study I: Skype SA[11]

Skype is a telecommunication provider that uses distributed computing to create an on demand telecommunications network. We first consider the underlying technology that highlights the initial operating success and the potential strategic opportunity to an acquirer. The unique operating practice explains how Skype was able to leverage distributed, on demand technologies, owned by its clients, to create a successful business venture. We then focus on Skype as a service provider and its acquisition by Ebay in 2005. A discussion of the fit between the services by Ebay and the services offered by Skype concludes this section.

Technology Description

Internet Protocol telephony (IP telephony), or voice over IP (VOIP), referred to voice calls that were transmitted over an IP network such as the Internet, rather than over the familiar circuit switched telephone network (PSTN). In a PSTN, telephone calls were routed based on a destination number and the geographical location of the called user. Thus, in a circuit switched network, first a connection was established before a call can begin. The topology of the telephone operator owned network dictated how calls are routed.

In the IP process, data were packetized, sent to a specific IP address and then reassembled at the destination. Packets were routed and rerouted through network hosts without a predetermined route until they arrived at the destination. Thus, no given package had to take the same route or to use the same network as the other associated packets. As such, IP-based communication did not require a proprietary infrastructure. However, since IP was a connectionless protocol, data corruptions, out-of-order delivery of the packets, or lost packets were common occurrences. While those effects could be mitigated through transmission of redundant packets, it provided challenges for the time critical delivery of voice data.

IP telephony evolved parallel to the Internet. In the late 1970s, experiments to transmit voice over ARPANET, the predecessor of the Internet, were undertaken. While these experiments demonstrated the capabilities of IP telephony, only some of the few individuals with access to ARPANET used these applications. The end user adoption of the WWW, fueled by the availability of the Netscape browser in 1995, led to the development of commercial VOIP applications.

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[11] The section draws on a previously published case study (Vitzthum, S., and Konsynski, B. 2008. "CHEP: The Net of Things," *Communications of the Association for Information Systems* (22:26), pp 485-500.). The detailed case write up is provided in Appendix A.

Early Commercial Applications

Released in March 1995, VocalTec's InternetPhone was one of the first VOIP software applications available to the public. Priced at USD 49.99 for two licenses, the software allowed free PC-to-PC calls between users who had installed the software client. The application included features such as a user-friendly interface, chat capabilities, collaboration tools such as white boards, and a directory of users online (Keating 1996).

While the client was quite sophisticated for its time, there were several technical hurdles that prevented mainstream adoption of the InternetPhone application and IP telephony in general. First, VOIP required high bandwidth to achieve satisfactory sound quality. At the time, most end users connected to their Internet Service provider via 14.4 or 28.8 Kbit modems. The most common approach to counter the bandwidth restrictions was to compress the packets. However, the early compression standards required processing power that most PCs could not provide at the time. Moreover, the lack of standard interfaces for auxiliary devices such as soundcards, more often than not led to compatibility issues.

The result of these early hurdles was a subpar user experience. The lack of bandwidth and processing power led to delays in the transmission and lost packages. Most of the time, only one user could speak; pauses during the conversation were the norm. However, despite the low quality of service, certain applications, such as overseas calling led to adoption.

In the fall of 1996, a major step toward improving the quality of IP communications was undertaken. At that time, the ITU-I, telecommunications standardization sector sanctioned by the United Nations, approved the H.323 standard as the international standard for multimedia communications over packet-based networks. The standard adoption had three major outcomes. First, it minimized hardware configuration issues that had slowed adoption of VOIP services in the past. Second, the unified standard allowed connections between the formerly separate software clients, increasing the network of users that could call each other. Third, and most importantly, H.323 also provided a gateway to the PSTN network, allowing for PC to landline calls.

Net2Phone, a subsidiary of calling card giant ITD, was one of the first companies to take advantage of the new standard. In 1997, it added PC-to-Phone to its existing PC-to PC service. By 1999, Net2Phone was the clear market leader in the VOIP market, claiming 1.5 million registered users. Despite being unprofitable at the time, the company received investments by Softbank and AOL. The initial public offering in July raised USD 80 million for 12 percent of its shares followed by the sale of an equal share for USD 384 million just five months later. Despite its success with the capital markets, Net2Phone never managed to live up to its promises. 2003 was the first profitable year for Net2Phone. By then the market capitalization had dropped to less than 5 percent of its initial value.

Several factors led to the demise of Net2Phone. From a market perspective, the Internet bubble had burst and investors were shying away from unprofitable companies. More importantly, users never switched to making VOIP calls, despite the potential cost savings. From a user perspective, calling from the PC was still inconvenient. Starting up the PC, plugging in the microphone and dealing with an unaccustomed user interface, did not lend itself to making a quick phone call. Moreover, broadband Internet, a major factor in VOIP quality, was only starting to be adopted in U.S. households.

By 2003, the VOIP market in the U.S. was highly segmented. There were numerous niche providers of PC-to-PC services that allowed their users to call each other. Also, MSN and Yahoo had equipped their Instant Messengers with voice capabilities. However, there was still a lack of interoperability between networks, leading to the inconvenience of having to use multiple clients to reach various contacts. In the PC-to-Phone segment, Vonage had become the new market leader. The Vonage service was marketed as a landline replacement, by offering hardware that would work independently of a software client and that could utilize existing telephones. However, pricing similar to existing PSTN contracts and the varying call quality only led to modest adoption. By 2003, only 150,000 paying Vonage subscribers were active.

A New Approach to Internet Telephony

Skype SA was the brainchild and second startup of Niklas Zennström and Janus Friis. Rather than focusing on a specific market, they focused on the possibilities of peer-to-peer (P2P] technology. In 2004, Zennström recollected (Oakes 2004): *"When Janus and I started [...] our vision was that peer-to-peer technology was kind of a fundamental technology that could be used for a whole lot of different business areas."*

P2P technology is a bundle of protocols that allow connected devices to form a decentralized network. By connecting to a peer to peer network, a user becomes part of the network and agrees to share computing resources such as processing power or storage to be utilized by the application that is used to connect to the network. It can be characterized as an *on demand* distributed network. In a true P2P system all nodes in a network join together dynamically to participate in traffic routing, processing and bandwidth intensive tasks that would otherwise be handled by central servers. P2P was popularized in the early 2000s with the rise of file sharing systems such as Napster and Kazza, which incidentally was the first venture of the Skype founders into the leverage of P2P.

In the summer of 2002, the two entrepreneurs decided to use P2P to create a telephony application. They formed the ambitious goal of providing a free and easy-to-use application that would enable users to have free telephone conversations over the Internet, eventually replacing landline phones. Being backed by small venture capital investments and supported by the same programming group that aided them to create Kazaa, they started their new venture in a small office in Luxembourg.

Within a year, the first beta version of their software was launched, enabling PC-to-PC telephony. Radically different from the traditional telecommunication companies, Skype incurred hardly any infrastructure-related fixed costs. By using VOIP, they utilized the free Internet infrastructure, and by deploying P2P distribution, they used the idle computing resources of their users rather than their own expensive servers.

The first beta version was launched in 2003, enabling only PC-to-PC telephony. Less than two months after the release of the first beta version, more than 1.5 million users had downloaded the Skype application. Within a year, this number had risen by over 100 million with more than 1.2 billion PC-to-PC voice minutes served. The second anniversary of the initial product launch revealed staggering numbers (2005b):

- More than 150 million downloads in 225 countries and territories
- More than 51 million people registered users (150,000 new users per day)
- More than 12 billion minutes served (more than 45 % of all U.S. VOIP traffic)

In 2005 Skype was still an unprofitable business. Revenue had increased from an estimated USD 7 million in the first year to nearly USD 60 million in the fiscal year of 2005. Gross margin was estimated at about 18 percent of the revenues, mainly due to the high cost of the landline connection fees (Blodget 2007a). However, Skype had managed to develop a successful product and become the VOIP market leader in the course of two years, using only USD 35 million in venture capital.

Discussion of On Demand Principles

In the introduction of the chapter we have identified four dimensions that lead to the success of on demand systems: an architecture that showcases on demand characteristics, the availability of complementary services, the composition competence of the platform provider and the matching of the solution space with the turbulence of the environment.

Architecture Characteristics

The founders of Skype leveraged several on demand principles to achieve their success. They used the Internet infrastructure instead of owning their own computing capabilities. In order to do so they developed a P2P application that would use the users distributed resources to perform the routing and processing of data. In addition, the founders anticipated that bandwidth will increase in the future, which would allow for time sensitive data to be packetized and reassembled to a timely fashion, which would minimize the delay during conversations.

In summary, Skype created an architecture that was interoperable and presented high degrees of modularity and coupling.

Service Availability

Skype also pushed to expand its range of services. Originally developed as a closed application with a proprietary protocol, the Skype client soon evolved into a programming platform. In 2005, the Skype Developer Zone opened to the public, allowing programmers to develop applications and features by themselves. Available documentation and frequent developer competition attracted a wealth of volunteer developers. In the three years of its existence, the “Skype sandbox” had much to show. More than 4,000 developers participated, creating more than 350 Skype-enabled applications (Willis 2007). Hence, Skype created a platform that fostered the development of external services. Thus, Skype evolved from an on demand ready platform to an on demand system.

Composition Competence

Skype took the freedom to test new services directly with its user base. Skype monitored the success of external services and than incorporated similar functionalities when the users voiced their need for those services as an official functionality of the Skype application. It rolled out new versions of its application that incorporated new services. Hence, Skype was able to facilitate external innovation, while closely guarding the services that would be incorporated in the official application. By differentiating between official and external services, Skype managed to keep control over the service composition while at the same time fostering development of new services.

Agility and Turbulent Environments

Despite the competition of more than 200 VOIP providers, Skype has managed to become the market leader in IP telephony. With more than 100 million loyal users, Skype has both the resources and the user lock in to fend off competition. Skype has continued to innovate to keep up with new service providers such as Google Talk, QQ or JahJah which compete for the same user base. Hence it appears that Skype successfully matches the turbulent environment by constantly creating new digital options.

Ebay's Acquisition of Skype

The success of Skype presented a unique opportunity to Ebay, as it presented a prospect for direct communication between buyers and sellers. Ebay had been very successful in integrating new services into their marketplace platform. Based on the users' feedback, and with the overall goal of providing frictionless commerce Ebay had acquired and integrated PayPal to not only facilitate market matching, but to also provide a seamless and trusted transaction settlement service. The integration provided an additional revenue stream for Ebay, while at the same time fulfilling a need for its user base. Connecting buyers and sellers to facilitate more and higher priced transactions seemed like valid extension of the strategy of adding services that both remove friction and provide additional revenue for Ebay. Hence, Ebay acquired Skype for a considerable price with the goal of integrating another value added service into its commerce platform

Architecture Characteristics

The inclusion of Skype can be considered as service integration into Ebay's higher order commerce platform. Skype was integrated into selected European test markets within a month of the acquisition, indicating that Ebay platform had sufficient degrees of interoperability, modularity and coupling to allow for a smooth integration.

Service Availability

At the time of the acquisition there were numerous third party applications that were used by Ebay users to facilitate voice communications. The acquisition of Skype was a surprise to many because it presented a commitment to a single service that was not deemed an essential part of the marketplace business. The investment limited external innovation to the extent that Ebay prohibited any other VOIP services from its marketplace. Ebay essentially stymied the VOIP service ecosystem hoping that Skype's past record of innovation along with tighter control over a single VOIP service would provide a viable economic alternative.

Service Composition

Synergies with the other eBay business lines were the main justification for the acquisition of Skype. The effort was dubbed "The Power of Three," indicating that three stand-alone growth businesses could be even more successful if they were integrated across the three businesses. The first integration took place between Skype and Paypal. Touted as a VOIP-enabled "Western Union," Skype's version 3.1, released in March 2007, included functionalities to send and receive payments from contacts with a click of a button. The global rollout of Skype in the Ebay marketplace followed in the Fall of 2007. The SkypeMe button allowed potential buyers to instantly call the sellers and ask about their listings. The feature was not well received by sellers that embraced the efficiency of listing multiple items, without having to have one on one communication with potential buyers. As a matter of fact, the ongoing concerns of the power sellers was cited as the main reason why the global rollout took place nearly two years after the acquisition. In 2009, Ebay removed Skype form its marketplace. Ebay recognized that it had failed from a service composition perspective. While the integration did not face any technological hurdles, it was not a sensible business maneuver. Ebay spent USD 3 billion and 4 years on a VOIP service integration experiment that failed. In retrospect, Ebay should have observed their users needs and behavior with different VOIP services and should have realized that it was not viable to invest into a single service, if it could have leased a number of others. Hence a market based approach to service integration would have saved a tremendous investment and would have led to the same result.

Case Study II: CHEP[12]

This case study traces the Information Systems development efforts of CHEP. CHEP wanted to create a distributed Information System which could sense real time location data for it over 100 million assets. The case of CHEP showcases how the integration of immature technologies and closed nature of the Information System architecture can lead to less than desirable business results.

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[12] The section draws on a previously Published case study (Vitzthum, S., and Konsynski, B. 2009. "EBay's Acquisition of Skype SA: Valuing the Voice of the Buyer," *Communications of the Association for Information Systems* (24:6), pp 89-104.). The complete case study is provided in Appendix B.

Description of Underlying Technology

Several technologies have been used to identify goods and assets in the supply chain. The most common form of product identification is the Universal Product Code (UPC), more commonly know as bar codes. Since their introduction as a standard retail identifier in the mid 1970s, bar codes had risen to ubiquity. Virtually every product sold in the U.S. had a UPC symbol consisting of a human-readable 12-digit UPC number and a machine-readable bar code. The first six digits are a unique manufacturer identification number that is assigned by the Uniform Code Council (UCC). The next five digits were the product code that uniquely identifies product groups and packaging size. The last digit presented a check digit that verifies the integrity of the previous 11 digits.

The bar codes enabled two major innovations in the retail industry. First, items could now be identified and associated with through a unique 12-digit number. Second, and more importantly, the machine-readability enabled semi-automated scanning, which improved the speed and accuracy of taking inventory or checking out at cash registers. The improved data quality also enabled retailers to analyze their sales and to track marketing efforts.

Despite the ubiquity of UPC and the success of related analyses applications, there were many settings and circumstances where barcodes were simply not a feasible solution to identifying and tracking items. The scanning of barcodes usually required a person that would either hold the item in front of a scanner or alternatively point the scanner directly at the bar code. For a successful scan, a proper reading angle, a fairly short distance (max. 2 feet) and a line of sight were necessary. Moreover, only one item at a time could be scanned, which incurred large lead times for sizable inventories.

In order to scan and track large amounts of assets bar codes were inadequate. In 1998, the Uniform Code Council, Gillette and Procter & Gamble teamed up with MIT to create the Auto ID center. The mission of the Auto ID was to develop and deploy technologies that would replace the UPC bar code. The center soon focused on Radio Frequency Identification (RFID) as an appropriate technology for replacing bar codes.

As a technology, RFID can be traced back to the 1930s. During the World War II, British planes would carry a transmitter, that when exited by radar waves, would broadcast a signal, identifying them as friendly aircrafts to the Allied radar station. RFID worked on the same basic concept: A tag, when exited by a radio wave sent by an external source, will reflect a slightly different signal back to the source. Based on the reflected signal, the source (or reader) can then identify tag.

A passive RFID tag could store 96 bit of information, allowing for a nearly infinite number of different Electronic Product Codes to be assigned. Thus, every tag and every associated item could be uniquely identified. In theory, a passive tag could be read from up to 10 feet away and no immediate line of sight was required for a successful read. More importantly, multiple tag readings were possible with a single scan. Thus, with the exception of water or metal blocking the radio waves, contents of entire warehouses could be read by simply walking or driving along the products, using a mobile reader.

Building The Net of Things

CHEP is the leading provider of rental pallets in the U.S. By issuing, collecting, conditioning, and reissuing pallets and containers from its service centers, CHEP supported manufacturers and growers to transport their products to distributors and retailers. Drawing from a pool of over 100 million pallets and containers, CHEP was only one of two pooling companies that distributed and collected its pallets across the entire U.S. Pallets accounted for nearly 90 percent of CHEP's pooling business.

CHEP was dependent on its supply chain partners to return the pallets but could not always enforce the return. By September 2000, CHEP reported that nearly 10 million pallets were missing. As a response, CHEP decided to experiment with RFID to solve its operational problems. The CHEP situation is noteworthy as they were a pioneer adopter of the RFID technology and early on recognized the strategic leverage possible through the employment in customer premise environments. The early adoption aspect presents a unique twist as standards had not been fully formed.

Maturing RFID

In 2000 RFID technology's theoretical capabilities had not been tested outside of a lab environment. Moreover, aside from prototypes, there were no commercial tags and readers available that would make a large scale implementation feasible. Thus, the CHEP management decided to become involved in the Auto ID imitative. CHEP agreed to provide the pallets fitted with RFID tags for potential field trials. The agreement was a big commitment, especially for a company that did not have experience with the emerging technology.

At the time, the choice of auto-identification technology was relatively easy, since only one company provided tags that were powerful enough to be read through common dock doors. The first challenge was to attach the tag to the wooden pallets. Tags could not be attached underneath the pallet because glue would not properly adhere to the wood. The option of affixing the tags to the top of the pallet was soon discarded since the tags would be exposed to constant wear through loading and unloading. The possibility of placing the tag inside the wood was also not feasible, since the material would partially block the transmission of the RF signal. With the lack of technological alternatives, CHEP engineers decided to attach a plastic board to the pallets where tags could be attached. This design worked until the pallets were loaded with products containing water or metal that interfered with the proper transmission of the RFID signal. The only technically feasible solution, a two-tag solution, could be implemented but was too expensive for a large-scale rollout.

Over the course of the next two years, the supply of RFID technology became abundant. Not satisfied with the outcome of the first prototype, CHEP started testing products from more then 30 technology vendors under various conditions. A team attached tags to different spots on the pallets and drove the pallets through a portal with readers. The team tested the tags in environmental chambers that brought the temperature down to -20 degrees Fahrenheit or up to 140 degrees. Moreover, they emulated real-world conditions by putting tagged pallets on a machine that simulated the vibration of trucks and by intentionally dropping containers to guarantee the performance of the RFID system in the field. In the end, an angled tag, attached to the center block of the pallet, proved to be the best design. The design fulfilled the stringent reading requirements while at the same time minimizing exposure to damage.

By 2001, CHEP's RFID team had become expert in RFID implementation. EPCglobal, the successor of the Auto-ID center, adopted CHEP's readability and testing requirements as the official standard. In addition, formal and informal links into the standard development community were established that helped CHEP to shape the future of the RFID technology. However, there were no immediate returns on investment from the RFID-related research. RFID was still not implemented to solve CHEP's operational problems, and research expenses started to accumulate.

Piloting the Technology in the Field

In 2003 CHEP initiated a pilot program where 250.000 pallets were tagged with RFID tags. Discovering supply-chain benefits was a challenging task. In order to take advantage of real-time data feeds into the readers at different locations, the data needed to be transmitted to a networked architecture. Integration problems quickly arose. Several applications needed to be integrated to capture, organize, and analyze the RFID data. To capture the data, CHEP had to implement an edge application that would enable the control of all readers, tags, and antennas. Moreover, the data needed to be integrated with the backend systems and the EPC network, in order to be shared across the supply chain. Lastly, the data needed to be analyzed. CHEP used warehouse management software from two vendors to manage the data at the distributor and retail level. The overwhelming amount of data, along with redundant reads, seriously burdened CHEP's existing IT infrastructure. Thus, the pilot became a trigger for developing in-house software expertise as well as upgrading the IT infrastructure. CHEP invested USD 100 million in SAP enterprise resource-planning software and a state-of-the-art data center at its Orlando, Florida, headquarters, hoping that the infrastructure would enable the company to manage millions of small transactions each time a pallet is used, to collect the associated fees and to understand the complex movements of its assets.

Pallet management was the most pressing problem facing CHEP. Nobody at CHEP really knew how the pallets were flowing through the supply chain. One pallet management objective was to simplify and optimize the asset flow. In 2003, the performance indicators became part of CHEP's robust monitoring and remote administration system, and in turn, this system was integrated with its existing legacy systems. For its RFID trial, CHEP only tracked the points of destinations for tagged pallets, which company returned the pallets, and whether they were damaged.

After two years of a sometimes frustrating process of trial and error, CHEP had perfected a way to put RFID tags on pallets and to ensure they can be read virtually 100 percent of the time. CHEP had gained invaluable RFID knowledge about tags, readers and the IT infrastructure needed to support them. In addition, CHEP had shaped the industry standards for RFID deployment and a technology expertise than was unmatched both in the supply chain or retail industry. Yet, it had also spent USD 20 million in researching and developing a new IT system that had yet to generate any return on investment.

Discussion of On Demand Principles

Architecture Characteristics

CHEP used standard protocols (EPC) to link the sensed data to its own information system. This enabled CHEP to gather and analyze data on demand. However, it failed to create standardized interfaces or an API to allow external parties to create valuable services. Essentially CHEP created an architecture that would only be used by a single, internal application.

Service Availability

The lack of external interfaces and interoperability with external forced CHEP to develop its own services. It started out by developing metrics that would allow for recognizing and analyzing internal operational inefficiencies. While CHEP usually relied on its ERP provider to develop additional services, SAP was not ready to provide new services that could leverage RFID. SAP actually moved its best practice unit to Orlando to be able to closer work with CHEP on integrating services based on RFID data into their system. Yet, while CHEP served as a pilot for SAP, no immediate services were developed that could aid CHEP beyond its internal operations.

Composition Competence

CHEP did not have the business acumen to create new services that would make joining the platform a valuable proposition for its clients. Manufactures were worried that simply tracking the goods would not aid them in their business planning and would only incur additional cost. Moreover, it was perceived by the majority of clients that CHEP wanted them to pay for a technology that would only create operational benefits for CHEP. Two years after the pilot, only few select clients had adopted the PLUS-ID service, enabling CHEP to pay and tag roughly 10.000 pallets per month with the revenues gathered from the service. After five years of testing, CHEP realized that the technology in itself does not generate sustainable revenues and that they were ill equipped to design new services that would attract new customers. In 2006 they started to create a new business unit, named Supply Chain Consulting that was charged with creating and selling services to potential customers. In summary, CHEP paid heavily for a technology without realizing that the technology needs to be levered to create services that make the adoption of RFID enabled pallets attractive to clients and external service providers.

Agility and Turbulent Environments

CHEP faced a low turbulence environment. Although there were a few challengers in the pallet pooling business, CHEP was the incumbent with the nation wide coverage and the largest pallet pool. The continuous growth of CHEP's pallet pool induced increasing complexity of the return processes and eventually shrinkage. CHEP's response was both a change of business processes and the introduction of RFID technology to better match the complexity of the environment. CHEP underestimated the cost of developing and on demand infrastructure while at the same time failing to scope the architecture as an open platform for services. It overmatched the complexity of its internal problems and now struggles to leverage the platform in the context of its client network. The study provides a prime example of overestimating the turbulence in an environment and over engineering a technological solution that does not create digital options outside of the initially intended scope.

Summary

CHEP had set out to create an on demand system to track its assets and to solve its operational problems. While the pilot had the expected outcome, there were no economies of scale associated with the system. CHEP had invested into IT infrastructure that did not benefit from network externalities. It also deployed the sensing technology (RFID) before it had matured. CHEP managed to shape the new communication standards for RFID. However, the company was not able make use of this standardization outside of the internal operational scope. In order to benefit from the platform it has created, CHEP needs to share the gathered information with customers who can then build service that can create value for CHEP's internal operations, the third party and the customer network as a whole.

Case Study III: Unmanned Systems

Unmanned Systems (UMS) are a new disruptive technology class that is rapidly changing the military landscape of the 21st century. First and foremost, UMS are reducing the footprint on the ground reducing the risk of life and limp. But beyond the mere substitution of troops, there are several new capabilities that are changing the way the military operates. The capabilities allow for better sensing of information and the creation of a *system of systems* that stretches control and influence beyond the edge of the conventional battlefield.

Current Use of the Technology

The Unmanned Systems Roadmap published by the Department of Defense (DOD) describes both the present reality and future paths for the advancement of unmanned and robotic warfare capabilities (DOD 2007). It defines an unmanned system as "a powered vehicle that does not carry a human operator, can be operated autonomously or remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload."

Sensing and responding are the two core missions of UMS. Initially UMS were developed and deployed to only sense information. Compared to human troops, most UMS can perform their sensing missions in a more persistent and precise manner. GlobalHawk for example, the premier reconnaissance unmanned vehicle, can fly un-refueled missions for over 30 hours at altitudes of up to 60.000 feet. While in flight, it can persistently monitor a radius of 60 miles for moving targets or spot focus on an area as small as 6 feet in a 4 square mile area.

While the UMS have potentially surpassed humans in collecting amounts of data over time, it still requires human operators to analyze the information and to make decisions in complex environments. Sensed data is usually transmitted to a base station and then manually rerouted by the operator for further processing to the respective military branch. While data is exchanged between branches, there is considerable delay in processing and compiling the data necessary for a best possible depiction of the current situation.

If real-time intelligence can be properly distributed, local commanders can synchronize action with other units and make informed decisions. A key challenge for the battlefield is to provide contextual knowledge to the right target at the right time. While UMS have increased both the volume and the granularity of the data gathered the context and quality of the data is still determined by the human officers.

Most UMS were designed for gathering data for situational awareness. A drone has the capability to survey a battle field from the air. A ground robot has a smaller range of motion, but it can provide more granular data regarding the situation within its range. The focus on situational awareness led to the design of UMSs which lead to the best local exploitation of capabilities. Battle Space Awareness which would require the exchange of information between different UMSs was not a design requirement when the UMS were initially specified. Hence, UMS were independent but also interoperable systems that suffered from stove pipe design. Currently the procedures of information sharing between systems and services operating the UMS are not standardized. Sharing of the information depends on the ability of the operators to interpret the incoming data and on the decision authorities granted in the controlling service.

According to ranking officers, most UMS use their own proprietary data standards, creating the need for human "interpreters" to translate and or analyze the data for further use by both troops and systems. This slows operations, introduces processing and technical error, and ties human resources that could be used otherwise. It leads to a piecemeal approach to collecting, analyzing and distributing information rather than to an integrated "system of systems".

Impact of On Demand Principles

Architecture Characteristics

Individual UMS are on demand service systems. They sense data in real time and transmit the information to the designated operator. The data are standardized and can be properly interpreted by the operator. The functionalities of the individual UMS are well encapsulated and it properly reacts to the input of the operator. The UMS interoperability profile, which is scoped for the communication of Unmanned Air Systems with their control station, requires that all transmission, collection, production and exploitation of gathered information needs to be undertaken in an interoperable manner. Interoperability in this context is defined as: "as the ability to provide, accept and use information, data and services, including technical exchange of information and the end-to-end operational effectiveness of that exchanged information as required for mission accomplishment”(DOD 2008).

The individual UMS are supposed to be components of a higher order distributed information system. While they provide high modularity, the systems are not directly linked. UMS suffer from proprietary communications protocols that do not interface with other non-human systems. The lack of standards for system to system communications and interfaces for data exchange prohibit system interoperability. Information processing is delayed because the data analyzed by operators in different branches and aggregated on a higher level between branches.

Service Availability

In the context of the UMS deployment, services are available in the form of capabilities provided by the individual UMS. However, the services can not be coupled into a system of systems because there is no interoperable platform that can bind the capabilities. Services are continuously created by investing in new UMS with better capabilities. Yet, an interaction between the UMS could create more options that could aid in creating battle space awareness.

Composition Competence

The composition of the service is undertaken through the chain of command. The military command deploys the UMS based on their best judgment. The goal of an integrated architecture would be to reduce overlap between situational data gathered by

UMS while at the same time creating a more holistic picture of the entire battle space. Until UMS can communicate in real time with each other and can exchange data on what area they have covered in a surveillance mission, the composition decisions will still have to be made by the commanding officers based on delayed information that had to be manually relayed and analyzed.

Agility and Turbulent Environments

The turbulence in a situation of persistent conflict is undisputed. Currently the turbulence is matched with investments in individual UMS that provide needed services. However, the creation of a UMS ecosystem that is loosely coupled by an integrated architecture or platform, could exponentially increase the information and options available for today's military. In order to become an *on demand* system of systems that can provide time sensitive data standard information architecture has to be deployed. The architecture will allow interoperability of assets and will enable sharing of sensed information across assets and services. Information needs to be standardized so it can be interpreted by the right entity, at the right place at the right time.

Summary

Information Systems that are applied in practice vary in their respect to the integration of on demand principles. The three cases show that the context of the operational environment and the scope of on demand systems determine their effectiveness. Skype built an application that creates a peer to peer network, based on a mature distribution system (the Internet), which operated on open standards and protocols. By using the resources of the connected peers, it was able to create and leverage a scalable telecommunications network that could be leveraged by the users. In addition Skype moved towards an open platform (by creating and API) that allowed third parties to create services that improved the experiences for the user. This allowed Skype to create a network effect where a large user base lead to the innovation of services, which in return attracted more users, making the network more valuable.

CHEP on the other hand, only partially benefitted from the existing infrastructure that was standardized. While they could transmit the gathered data via standardized protocols to their data center, they had to experiment with the functionality and transmission standards of RFID. Their main focus was making the sensing of the data work. The company did not intend for leveraging the gathered data outside of the improvement of the internal operations. Thus, the system and the acquired data remained proprietary. The envisioned on demand system became a commercial failure because of those design flaws. Since neither CHEP nor external providers were able to create services that would have made the gathered data valuable for customer, they were not able to recoup the previous or justify further investments for creating a true on demand system.

The case of the UMS deployment brought forward another dilemma of on demand systems. Although individual systems can provide on demand information, there is a need to standardize the system output not only for human interpretation but also for system interpretation. The systems worked well in there prespecified scope in gathering data related to situational awareness. However, while they were modular in the sense they did not rely on other systems to perform their functionalities, they could not be coupled with other systems, because there were neither inter-system interfaces nor communication standards, nor was there a non-human system in place that could process the data.

The analyses of the in practice on demand systems show that there is no single approach to developing and leveraging an *on demand* system. Different contexts provide different levels of infrastructure maturity, technology cost and tremendous variation in the open or closed nature of the systems. Despite the differences, there is evidence that systems which are designed as both composite platforms *and* as potential components of a larger system of systems tend to create more digital options for the owning entity. It remains to be seen whether these digital options are sustainable and whether they can create a long term competitive advantage for the systems' creator.

CHAPTER VIII: CONCLUSION AND FUTURE RESEARCH

This research effort employed several lenses and perspectives to gain an understanding of evolving models of on demand computing and service provision. In considering the presence of key on demand principles I utilized descriptive analysis, simulation and modeling. In the several studies represented in this research effort, I explored the presence and absence of several of the key principles underlying the on demand environment in order to understand and predict innovative directions in the migration toward, and beyond, cloud computing environments and future computing paradigms.

The principles of on demand environments are present in many of the evolving architectures as evident in the presented cases and simulations. The studies illustrate that the impact of on demand systems is also dependent on the characteristics of the external and technological environment. The role of the external environment on the internal architecture and operating environment has been investigated throughout the several studies of this dissertation. The initial chapter on the principles reviewed the changes in the external environment in regard to the evolution of information systems and the related trend of decreasing cost for the three computing utilities; storage, processing and bandwidth. This technological shift has enabled new forms of information systems, which in turn has spurred the rise of new business models and computing services. The boundary spanning nature of evolving architecture is evident in the evolution of willingness to outsource over time. What began as environments to leverage the economies of scale for expensive and complex mainframe environments (time sharing), evolved into an increasing willingness to outsource operations, applications, shared data and eventually whole segments of development. Each of these evolutionary steps serve an increasing adoption of the key principles of on demand computing that have been central to these studies.

The impact of on demand systems also depends on the digitalization of the external environment. The case study on CHEP has shown that there are numerous challenges associated with the aspiration to create an on demand system. An on demand system thrives if external providers can make use of the system by creating services of their own. However, a lack of external interoperability of the system in combination with a lack of interest and IT competence by core customers precluded from CHEP's "Internet of Things" to have an impact on the supply chain and the industry as a whole. The case of the UMS deployment provided a hybrid digitalization of the environment. While the systems gathered and transmitted digital information, it was rerouted and processed by human operators. The discussion has shown that an extension of the systems where the UMS can communicate and coordinate with each other and where the gathered information could be processed by an integrated information capability that would have a great impact on analyzing the entire battle space in real time. The digitalization of the environment was also investigated in the chapter on information diffusion. Information and communication technologies have not only allowed an increase in the *democratization of access* and the *democratization of participation* but they have also allowed for the speedier convergence of information. Although the study was set in the space of end users forming an opinion, conclusions can be drawn for the impact of information diffusion in other all-digital environments. Depending on how market or industry information networks are structured, competitive information will quickly spread throughout the network. While this can have positive effects, such as a quick consensus on industry wide standards, it also will decrease the chances of prolonged exploitation of valuable information. Not only will this information surface quicker in an all-digital environment, but the digitalization will also enable competitors to immediately respond to actions taken based on the information.

A third aspect of the external environment was examined in the study of the alignment between architecture and environment: turbulence. The study subsumed dimensions of turbulences such as economic shift, changing consumer preference or regulatory changes and examined how drastic changes in one or all dimensions can be countered if not leveraged by on demand systems that are based on service orientation principles. The factors of the external environment that influence the impact of on demand systems are depicted in Figure 19.

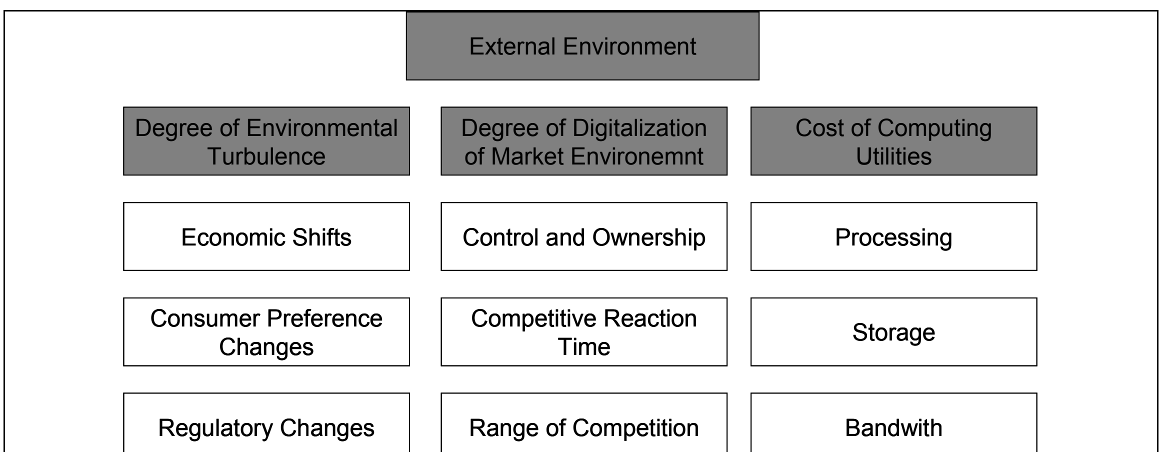

Figure 19: Dimensions of the External Environment

Aside from the external environment, the impact of on demand principles is also governed by the internal and external technological environment. At the core of this dissertation have been the introduction and the evaluation of service orientation, and the three related characteristics: interoperability, modularity and loose coupling. The study on alignment showed that all three characteristics had a positive impact on aligning with the external environment. The case study on Skype provided an example of how the transition to an interoperable system can create a service ecosystem that benefits the external service providers, the platform provider and the users. CHEP on the other hand focused on building a closed platform was not interoperable with external systems, thus limiting the impact of the on demand system. The UMS study showed that there is value in systems that are modular, albeit not interoperable or loosely coupled. However, it also became evident that if the latter two characteristics were applied, a system of systems might emerge, which would have a far greater impact than the sum of its parts. The information diffusion brought light to a different aspect of interoperability. If an actor, human or non-human, can interact because they find a common denominator that lets them interact and exchange information, a convergence of ideas of can occur.

The second dimension of the technological environment is concerned with the systems composition competence. The alignment study showed that both based on the findings of prior research and the outcome of the computational model, IT competence aides in the composition of adaptable systems. The discussion on the overarching philosophies of service orientation showed that there is a dynamic aspect to the composition of on demand systems. Whether the dynamic composition will be best achieved through manual labor provided by IS human resources or by automated or automatically based on algorithms or the collective mind of the systems, is a question for future research. However, advances in the cognitive intelligence of UMS and the automated dynamic construction of Skype's peer to peer network provide evidence that system based composition will become a reality in the near future.

The third dimension of the technological environment was introduced in the chapter on the principles of on demand systems. The extent of on demand systems will depend on a functioning market for services. Services will have to be available, findable and in competition with each other to enable on demand systems. While the early theories on this market predicted that a central repository of services would emerge, there seems to be a different trend that provides a similar effect. Services are bundled in a cloud environment and then delivered to requesting entities – in a "publish and subscribe" fashion, similar to web service environments and many social media settings, like Twitter and blogging. Most services are currently offered free of charge by large cloud players like Google or Microsoft. Despite the fact that there is no monetary exchange taking place, it doesn't mean that we are not approaching the transactional web. Services are delivered with limited functionality in order to charge for more comprehensive incarnations or as it is the case with Google they are being paid for through advertisement embedded in the service. While the market for services is not as decentralized as initially predicted, there are signs that a market is developing. Due to Facebook's or Apple's APIs, developers have embraced the opportunity to develop services that compete for the user's attention and in the case of Apple's appstore for their wallet. A similar service market has yet to emerge, but once mechanisms such as authentication, security and billing are standardized, it too will become reality. The dimensions of the technological environment are depicted in Figure 20.

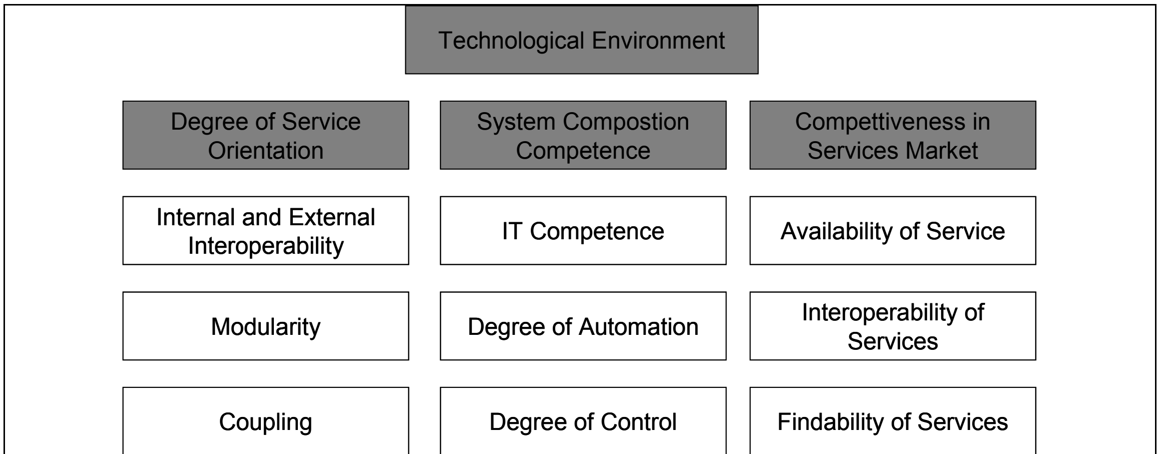

Figure 20: Dimensions of the Technological Environment

Future Research Directions

The integrative aspects of on demand environments weave the common elements of grid, automatic, utility and cloud computing together in the framework and principles of on demand services and capabilities. We can little doubt the implications for transforming the development and management of the IT artifact and operations. Trends like global outsourcing, RAID storage and web service provision align with these studies. As has been show, the key principles of on demand environments offer a basis for comparison and contrast of the issues in evolving grid, utility and automatic computing environments.

It would be difficult to doubt the necessity of adoption of these key principles of the on demand environments. It seems inevitable and necessary. We might expect simpler systems, democratically produced, by hands that are more familiar with business policy than with programming. There is little choice in the risk-related volatility as we enter the second decade of the twenty-first century. While the world maintains a large number of system developers with technical skills, new approaches are still needed in the volatile demands of the global marketplace.

Many aspects of the on demand environment suggest a migration to these principles being an integral part of the emerging cloud environments. The advent and emergence of forms of cloud computing suggest significant prospects to continue and extend this research in several dimensions. The research will extend to an examination of specific implementation of many of the key principles in the cloud computing environment.

In addition, the critical questions of *private* versus *public* clouds and inter-cloud standards are a natural extension. What content can/should be suitable for public cloud environments? What would require extra protection? How might the protection (e.g. encryption) be supported without diminishing the value of the cloud environment?

Another avenue to pursue would be the development of adaptive systems in these on demand environments. How will complexity be managed? What lessons might be learned from the realm of open systems sharing and the veracity, reputation systems and integrity of "other" sourced systems?

While the studies that are a part of this effort have focused on the key principles governing several of the evolutionary trends of on demand environments, they represent a dynamic model of trends in governance and control. Trends in accessibility (ubiquity), democratic production, filtering and editing (e.g. reputation systems), and efficient markets for data and web service syndication – will further shape this landscape. We have many new questions to explore.

APPENDIX A: CHEP

PART A: CHEP: The Net of Things

Introduction

In the early 2000s the major retail chains moved beyond the boundaries of the enterprise to further improve their operations. One particular focus of companies such as Wal-Mart, Tesco, and Metro was the optimization of the entire supply chain. While Electronic Data Interchange (EDI) had connected supply chains a decade earlier, the quality and accuracy of the information shared was by no means satisfactory. The emergence of Radio Frequency Identification (RFID) provided the technology needed to capture accurate and timely item-level data, information that was deemed crucial to optimize the product and information flow throughout entire supply chain.

CHEP, the leading provider of rental pallets in the U.S. was both an integral part of most major supply chain operations and an early adopter of RFID. Having invested more than $20 million in the research and development of RFID enabled pallets, the CHEP management was under increasing pressure by its parent company to monetize on its innovations beyond efficiency gains in its internal operations.

By championing RFID, CHEP had put itself in the position to enable change on the enterprise, supply change and industry level. However, inducing technology enabled change while at the same time maintaining a profitable core business posed a unique challenge for CHEP. Unsure of how to best market the new technology to clients and partners, CHEP had to decide whether they just want to offer enhanced RFID pallets for its clients, or to become a supply chain wide information broker.

Industry Background

A pallet is a platform, usually made of wood and assembled with metal nails. Typically, goods move in commerce from their manufacturer to distributors, to wholesalers, and finally to retailers, where they are made available for purchase by the consumer. Wooden pallets are used for purposes of hauling, loading and unloading, and storing the goods. The wooden pallet has traditionally been the basis for the design of storage racks, warehouse storage areas, forklifts, docks and containers used in shipping goods. It is estimated by industry sources that on average there are more than seven pallets for each person in the United States. According to a survey conducted by the National Wooden Pallet and Container Association, 91 percent of pallet users reported using wood pallets, with the remainder being made from other materials such as steel, plastic, or cardboard.

By 2003, the U.S. pallet industry generated revenues of approximately $6 billion, and it was served by approximately 3,600 companies, most of which were small, privately held entities. These companies were generally operating in only one location and serving customers within a limited geographic region. The industry was generally composed of companies that manufacture new pallets and companies that repair and recycle pallets. The U.S. Forest Service estimated that 475 million new wood pallets are produced annually, 300 million wood pallets were repaired and sent back into circulation, and 175 million wood pallets were sent to landfills.

The pallet industry, a generally mature industry, had experienced significant changes during the 1990s. These changes were due, among other factors, to the focus by Fortune 1000 businesses on improving the efficiency of their supply chains, manufacturing, and distribution systems. This focus had caused many of these businesses to significantly the number of vendors serving them to simplify their procurement and product distribution processes. Palletized freight facilitated movement through the supply chain reduced costly loading and unloading delays at distribution centers. As a result, there had been an increased demand for high-quality pallets which decreased the cost per trip by reducing product damage during shipment and storage and by increasing the number of trips for which pallets can be used. Moreover, environmental and cost concerns had also accelerated the trend toward increased reuse or "recycling" of pallets and certain other transport packing materials, further emphasizing the importance of the quality of newly manufactured pallets.

Shipping companies had a variety of options for procuring pallets. Traditionally, companies would buy the pallets, load the goods, and send them to their clients. Depending upon the size and make-up of the operations, businesses would decide whether to opt for single-use, lower-quality pallets that are not returned by the customers or for higher quality, reusable pallets, where the return processes would need to be arranged with the customers. The administrative, operational and logistical costs associated with managing the pallets, led to the emergence of third-party providers that started to lease out high-quality pallets and offer management of the associated logistics. In the outsourced rental model, shippers paid a combination usage and transfer fees that usually amounted to total trip costs ($5-$8) that are below the purchase price of a one-way pallet ($10).

By 2003, more than 10 percent of the 2 billion pallets that were in circulation in the U.S. were provided by pallet leasing or pooling companies. While the asset share in the overall market was fairly small, the pooling and leasing of the pallets was a highly profitable business. The major pallets pooling providers generated close to $2 billion in annual revenue and were expected to grow both their market share and revenue in the future.

Competitive Landscape

In the U.S., pallet pooling was a fairly novel business model with few national providers and some regional providers. By 2003, approximately 200 million pallets in circulation were multi-use rental pallets. In 1990 CHEP entered the U.S. market as the first provider with a national distribution network in the U.S. Throughout the consolidation of the pallet industry in the 1990s a number of companies entered and exited the pallet pooling business. Between 1990 and 1996 companies such as First National Rental, Pallet Pallet and the Canadian Pallet council tried unsuccessfully to establish a pallet rental program in the U.S. The most common issue for the companies was the fairly small size of their pallet pool as well as low distribution center density, which increased the cost of shipping pallets. In 1997, PECO, a consortium of 12 pallet companies, was the first company to develop a rental system that could compete with CHEP's. Focusing on the grocery industry, PECO management decided to work with only a few clients and a competitively small pallet pool of 2 million. The strategy worked, and by 1999 PECO became the second largest rental provider in the U.S. Besides the two market leaders, only regional companies such as Kamps Pallets in Michigan were able to make the pallet pooling model work. Moreover, there were several attempts to introduce plastic pallet pooling models as a more environmentally friendly alternative to wooden pallets. However, the higher manufacturing costs and the resistance of industry organizations to adopt plastic pallets as a standard led to a quick demise of those efforts.

By 2003, CHEP was the undisputed market leader in the U.S., at situation which mirrored the developments of most of the countries where CHEP operated in. Being the pioneer of the pallet pool-leasing model, CHEP was the market share leader in 90 percent of the 42 countries that it operated in.

Company Background

The Commonwealth Handling Equipment Pool (CHEP) evolved from the Allied Materials Handling Standing Committee, an organization developed by the Australian government to provide efficient handling of defense supplies during World War II. In 1949, the government decided to privatize the industry and mandated the sale of the CHEP organization. Among CHEP's core assets were vast amounts of pallets, forklifts, and cranes left by the allied forces.

Brambles, a company created in 1875, had significant experience in the materials handling industry, acquired CHEP in 1958. The acquisition of CHEP empowered Brambles with new core competencies making it ready to meet the constantly growing demands of the materials-handling industry. In particular, Brambles was interested in exploiting the large pool of pallets and containers, and taking advantage of the scale that this pool of platforms provided. Within a few years CHEP, leased out and operated the largest pool of pallets and containers in the southern hemisphere and the largest hiring fleet of forklift trucks in Australia. With the acquisition of the British firm GKN, CHEP set up a UK branch in 1974, followed by CHEP Canada in 1980, and CHEP USA in 1990.

By 2003, CHEP was the global leader in pallet and plastic container pooling services, supporting many of the world's largest companies. With its global headquarters located in Orlando, Florida, CHEP employed more than 7,500 employees in 42 countries at more than 500 service centers. On a global scale, the company generated approximately $US 3 billion in revenue by pooling more than 200 million pallets and more than 40 million containers worldwide. In 2003, CHEP served more than 75,000 consumer good manufacturers and produce growers (manufacturers) and 225,000 wholesalers and retailers (distributors).

Business Model

By issuing, collecting, conditioning, and reissuing pallets and containers from its service centers, CHEP supported manufacturers and growers to transport their products to distributors and retailers. Drawing from a pool of over 100 million pallets and containers, CHEP was only one of two pooling companies that distributed and collected its pallets across the entire U.S. Pallets accounted for nearly 90 percent of CHEP's pooling business.

CHEP leased high quality, standardized and easily identifiable (all CHEP pallets are painted blue) 48" by 40" pallets. The pallets were designed for multiple uses. Deploying high-quality softwood and reinforcing design, the pallets weighed 60 lbs. and could hold up to 2,800 lbs. of goods. In comparison, a standard pallet was 15 lbs. lighter and could only carry up to 1500 lbs. With an average of $20 of procurement cost, the CHEP pallets were also twice as expensive as the regular single-use pallets. By using CHEP's pallets, clients had reduced transportation costs and reduced product damage due to more stable storage arrangements which would prevent weight shifts of the loaded goods. Moreover, softwood pallets were less likely to break when mishandled during transportation, loading and unloading. With higher payloads per pallet, transporters could improve vehicle utilization and provide faster turnaround times. Moreover, through the standardized design of the pallets, products could be unloaded faster and safer. In addition, the reusability of the CHEP pallets reduced disposal expenses at land fills.

CHEP's asset flow model was designed for closed-loop systems, where all supply-chain links are in a contractual relationship with CHEP. Initially, pallets were issued to manufacturers that could subsequently load goods onto the pallets. During this step, CHEP would charge the manufacturer an issue fee, which was related to the transport of the pallets from CHEP's service centers to the manufacturer's location, and a hire fee based on the days that the pallets were in the manufacturer's possession. When the loaded pallets were shipped to the distributors, CHEP charged a transfer fee to the distributors. The distributors then had to pay a daily hire fee while they used the pallets and a recollection fee upon returning the pallets. Ideally, CHEP would collect all fees from the parties involved and receive all of its pallets at the service center, where pallets were sorted (A), refurbished if necessary (B), and reissued (C).[13]

On average, a pallet trip through the closed loop took 44 days. It was estimated that CHEP charges a total of $5 to $6 in fees per pallet for an average trip. Since it charged a variety of variable and fixed fees from different clients, CHEP had tremendous administrative cost associated with billing the correct amount to each partner. Moreover, CHEP heavily depended on inventory reports by the clients (which are seldom verified) and random sampling to assess the correct fees.

[13] The closed-loop asset flow is depicted in the shaded area of Figure 21.

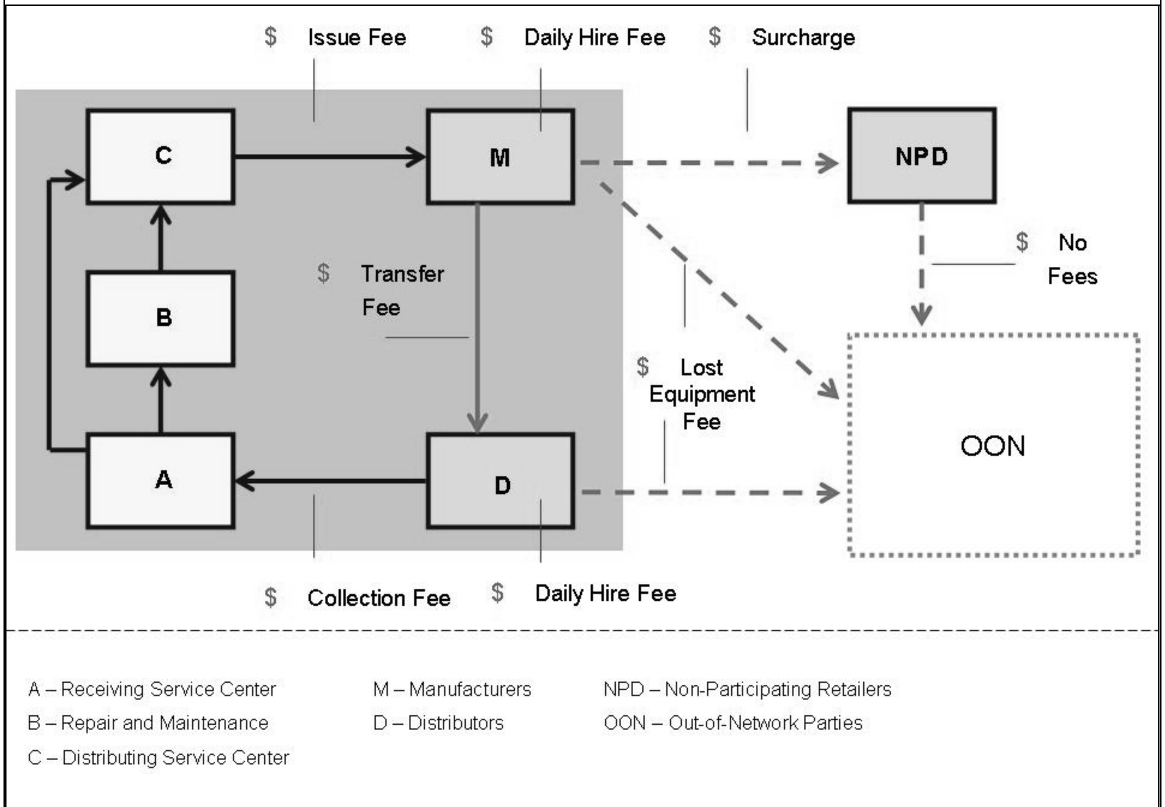

Figure 21. Asset Flow and Pricing Model

In the original closed-loop model, CHEP had contract relations will all participating parties. In the past, CHEP had a fairly good record of tracking the pallets and billing the clients. However, with the rise of contracts and the growth in scale, pallets frequently were shipped outside of the network, making it impossible for CHEP to track pallets and enforce their return to the service centers. CHEP introduced several charges and penalties for its clients to limit pallets moving outside the closed-loop system. In 1998, it introduced surcharges ranging between $3.50 and $8.00 for preferred manufacturers that would ship pallets to so called Non-Participating distributors (NPD), which had no contractual obligation to return pallets to CHEP. All non-preferred clients that could not return all pallets, because they were shipped outside of the CHEP network, were charged a “lost equipment fee” ranging from $20 to $24. However, it was CHEP’s burden to prove that (a) the pallets had actually left the closed loop, and (b) which party was responsible for the leakage and eventual loss of the pallets.

By September 2002, CHEP reported that nearly 10 million pallets were leaked outside of the closed loop. About 3 million pallets could be tracked to known NPDs that had no obligation to return the pallets to CHEP. The other 7 million pallets were lost to out of network parties such as pallet recyclers or end-users who were hesitant to return the pallets or not aware that the blue pallets were rental property rather then part of the purchased goods. If CHEP could not collect those pallets, it would have to pay up to $21 per pallet for replacements or face losing annual revenue of $9 to $13 per pallet.

As an initial response, CHEP collaborated with a substantial number of out-of-network parties as part of their Asset Recovery Program and raised the awards for returned pallets. Moreover, a budget of $20 million was set aside for activities to recover and collect lost pallets. However, trying to recover lost pallets was merely a short-term solution of the symptoms rather than a long-term cure of for lack of traceability of and accountability for the pallets.

Discovering the Potential of RFID

In the mid 1990s, CHEP began to explore ways to improve asset tracking and customer service. At the time, the most common form of product identification was Universal Product Code (UPC), more commonly know as bar codes. Since their introduction as a standard retail identifier in the mid 1970s, bar codes had risen to ubiquity. Virtually every product sold in the U.S. had a UPC symbol consisting of a human-readable 12-digit UPC number and a machine-readable bar code. The first six digits are a unique manufacturer identification number that is assigned by the Uniform Code Council (UCC). The next five digits were the product code that uniquely identifies product groups and packaging size. The last digit presented a check digit that verifies the integrity of the previous 11 digits.

The bar codes enabled two major innovations in the retail industry. First, items could now be identified and associated with a through a unique 12-digit number. Second, and more importantly, the machine-readability enabled semi-automated scanning, which improved the speed and accuracy of taking inventory or checking out at cash registers. The improved data quality also enabled retailers to analyze their sales and to track marketing efforts.

Despite the ubiquity of UPC and the success of related analyses applications, there were many settings and circumstances where barcodes were simply not a feasible solution to identifying and tracking items. The scanning of barcodes usually required a person that would either hold the item in front of a scanner or alternatively point the scanner directly at the bar code. For a successful scan, a proper reading angle, a fairly short distance (max. 2 feet) and a line of sight were necessary. Moreover, only one item at a time could be scanned, which incurred large lead times for sizable inventories.

For CHEP's purpose of tracking millions of individual pallets, bar codes were inadequate because most stacked pallets were outside of the reading distance or hidden behind other pallets. Moreover, the labor required to scan individual pallets at different location was enormous. Looking for alternative tracking technologies, CHEP management soon took note of the formation of the Auto ID Center and joined it as one of its first sponsors. In 1998, the Uniform Code Council, Gillette and Procter & Gamble teamed up with MIT to create the Auto ID center. The mission of the Auto ID was to develop and deploy technologies that would replace the UPC bar code. The center soon focused on Radio Frequency Identification (RFID) as an appropriate technology for replacing bar codes.

As a technology, RFID can be traced back to the 1930s. During the World War II, British planes would carry a transmitter, that when exited by radar waves, would broadcast a signal, identifying them as friendly aircrafts to the Allied radar station. RFID worked on the same basic concept: A tag, when exited by a radio wave sent by an external source, will reflect a slightly different signal back to the source. Based on the reflected signal, the source (or reader) can then identify tag.

A passive RFID tag could store 96 bit of information, allowing for a nearly infinite number of different Electronic Product Codes to be assigned. Thus, every tag and every associated item could be uniquely identified. In theory, a passive tag could be read from up to 10 feet away and no immediate line of sight was required for a successful read. More importantly, multiple tag readings were possible with a single scan. Thus, with the exception of water or metal blocking the radio waves, contents of entire warehouses could be read by simply walking or driving along the products, using a mobile reader.

However, by 1999 the technology's theoretical capabilities were not tested outside of a lab environment. Moreover, aside from prototypes, there were no commercial tags and readers available that would make a large scale implementation feasible. Thus, the CHEP management decided to become involved in the Auto ID imitative. CHEP agreed to provide the pallets fitted with RFID tags for potential field trials. The agreement was a big commitment, especially for a company that did not have experience with the emerging technology.

At the time, the choice of auto-identification technology was relatively easy, since only one company provided tags that were powerful enough to be read through common dock doors. The first challenge was to attach the tag to the wooden pallets. Tags could not be attached underneath the pallet because glue would not properly adhere to the wood. The option of affixing the tags to the top of the pallet was soon discarded since the tags would be exposed to constant wear through loading and unloading. The possibility of placing the tag inside the wood was also not feasible, since the material would partially block the transmission of the RF signal. With the lack of technological alternatives, CHEP engineers decided to attach a plastic board to the pallets where tags could be attached. This design worked until the pallets were loaded with products containing water or metal that interfered with the proper transmission of the RFID signal. The only technically feasible solution, a two-tag solution, could be implemented but was too expensive for a large-scale rollout.

Over the course of the next two years, the supply of RFID technology became abundant. Not satisfied with the outcome of the first prototype, CHEP started testing products from more then 30 technology vendors under various conditions. A team attached tags to different spots on the pallets and drove the pallets through a portal with readers. The team tested the tags in environmental chambers that brought the temperature down to -20 degrees Fahrenheit or up to 140 degrees. Moreover, they emulated real-world conditions by putting tagged pallets on a machine that simulated the vibration of trucks and by intentionally dropping containers to guarantee the performance of the RFID system in the field. In the end, an angled tag, attached to the center block of the pallet, proved to be the best design. The design fulfilled the stringent reading requirements while at the same time minimizing exposure to damage.

By 2001, CHEP's RFID team had become expert in RFID implementation. EPCglobal, the successor of the Auto-ID center, adopted CHEP's readability and testing requirements as the official standard. In addition, formal and informal links into the standard development community were established that helped CHEP to shape the future of the RFID technology. However, there were no immediate returns on investment from the RFID-related research. RFID was still not implemented to solve CHEP's operational problems, and research expenses started to accumulate. By the end of 2001, the future of the project was in doubt. Fortunately, for the project, a new CEO was appointed in February 2002. Victor Mendes immediately saw the value of RFID, but he also was worried about the slow progress. He decided that the technology had to be implemented immediately instead of further testing it in controlled environments.

The Pilot

Donna Slyster, senior VP of operations, was put in charge of a team that included people from CHEP's IT, engineering, operations, and asset management departments. Having worked at EDS and General Motors, she was familiar with the implementation of new technologies. In order to have tight control over the pilot operations, Slyster decided to roll out the pilot close to the Florida headquarters. The team tagged 250,000 pallets with the aim of tracking them as they moved among 34 manufacturer locations and back to any of the six Florida service centers.

The Florida pilot had three distinct objectives: to “pressure test” the technology in a real-world setting, to identify supply chain and pallet management benefits, and, most importantly, to provide evidence for future investment decisions in RFID. As Slyster reflects:

We wanted to see if it was feasible to use RFID to track pallets through the supply chain. We wanted to understand the benefits we could achieve internally and for our customers.

From a technology standpoint, CHEP already knew what to expect from RFID and how to fine-tune potential flaws. For instance, there were no products designed for mounting readers around dock doors, so CHEP engineers built a reader stand from pipe, fastened it to the doorway, and painted it yellow. Then they mounted four RF antennas to the pipe, two on each side. Cable was run from the antennas to a wall-mounted reader. Five dock doors, through which pallets enter the building, and two exit doors were fitted with this setup six distribution centers. In order to improve the durability of the tags, engineers also designed custom-made plastic cases that could withstand pressure, water, heat, and UV radiation. While this casing increases the cost of a single tag to $1, the life span of a tag now seemed infinite.

Discovering supply-chain benefits was a more challenging task. In order to take advantage of real-time data feeds into the readers at different locations, the data needed to be transmitted to a networked architecture. Integration problems quickly arose. Several applications needed to be integrated to capture, organize, and analyze the RFID data. To capture the data, CHEP had to implement an edge application that would enable the control of all readers, tags, and antennas. Moreover, the data needed to be integrated with the backend systems and the EPC network, in order to be shared across the supply chain. Lastly, the data needed to be analyzed. CHEP used warehouse management software from two vendors to manage the data at the distributor and retail level. The overwhelming amount of data, along with redundant reads, seriously burdened CHEP's existing IT infrastructure. Thus, the pilot became a trigger for developing in-house software expertise as well as upgrading the IT infrastructure. CHEP invested $100 million in SAP enterprise resource-planning software and a state-of-the-art data center at its Orlando, Florida, headquarters, hoping that the infrastructure would enable the company to manage millions of small transactions each time a pallet is used, to collect the associated fees and to understand the complex movements of its assets.

Pallet management was the most pressing problem facing CHEP. Nobody at CHEP really knew how the pallets were flowing through the supply chain. One pallet management objective was to simplify and optimize the asset flow. Slyster and Mendes created performance indicators that could be calculated with the data gathered through RFID and checked daily. In 2003, the performance indicators are part of CHEP’s robust monitoring and remote administration system, and in turn, this system was integrated with its existing legacy systems. Although Slyster would not exactly quantify the benefits for the pallet management operation, she contended that the results were convincing enough to launch a service offer for customers. For its RFID trial, CHEP only tracked the points of destinations for tagged pallets, which company returned the pallets, and whether they were damaged. Tracking the pallets originating from the 34 locations was a straightforward task, but as the system would expand and the amount of data mushrooms, the ability to capture, organize, and analyze the data would become important for CHEP and its customers.

After five years of a sometimes frustrating process of trial and error, CHEP had perfected a way to put RFID tags on pallets and to ensure they can be read virtually 100 percent of the time. CHEP had worked with a RFID manufacturer and created a tag that could be embedded in plastic and bent around the center vertical support block in a pallet. The tag was well protected and could be read regardless of the pallet's orientation. CHEP had gained invaluable RFID knowledge about tags, readers and the IT infrastructure needed to support them. CHEP had shaped the industry standards for RFID deployment and a technology expertise than was unmatched both in the supply chain or retail industry.

After the Pilot

Following the pilot, Slyster was promoted to CIO, and CHEP's RFID program was put under the leadership of Brian Beattie, SVP of Marketing. Puneet Sawhney was appointed as the Program Manager for RFID, and reported directly to Brian. The leadership team decided that for CHEP's RFID program to succeed in the current environment, it had to be marketed to its supply-chain customers. Although the pilot was a technological success that helped CHEP to understand its own business processes on a small scale, there was no immediate return on the $20 million investment in the technological development. If Brian and Puneet could convince key accounts to adopt RFID and to build the network infrastructure, CHEP could trace the product-flow of its assets. Since the CHEP business model involved transfer of pallets when they are shipped from its service center to the manufacturers and then to the retailers, better information sharing would be a win-win situation for all the parties, leading to real-time asset management and control.

Around June 2003, when CHEP concluded its pilot, a major event in the industry changed the pace of RFID adoption. Wal-Mart announced a January 2005 deadline for its top 100 suppliers to begin shipping on RFID-enabled pallets and cases. If widespread adoption is what makes any technology successful, then the Wal-Mart announcement would be the reason for RFID's success in the retail supply chain. With an annual turnover of $260 billion, Wal-Mart was the largest retailer in the world and is capable of setting the agenda for retail supply chains.

For retailers, key RFID features and the derived benefits of this technology made a compelling case. Through real-time data capture, a finer granularity of information capture and accurate information-sharing processes could be automated that would lead to reduced labor and product-handling costs. Also, revenues could be increased through better inventory management and the reduction of out-of-stock losses. However, despite theoretical benefits, the reactions of both suppliers and retailers to the new technology proved difficult to gauge.

Moving Forward

After reviewing their clients' current initiatives, Brian and Puneet were convinced that they had a solution that would address both their clients' needs and the improvement of internal operations. If the main fears of the manufacturers were cost and lack of expertise with the technology, CHEP could provide an economical solution for the pallet tagging. Instead of affixing a new tag to cases every time an order is shipped, it would simply read the code of CHEP's pallet, which then could be associated with the loaded products. In that scenario, the manufacturers would save on variable costs and would have a small, fixed-cost investment in the readers and the connection to the back-end systems. Renting the RFID-enabled pallets would be slightly more expensive, but the client's net costs would be far less than the expense of developing their own RFID solution.

The Wal-Mart compliance requirements of the client were well aligned with the new "PLUS ID" Service. For a surcharge of US$ 0.49 per pallet trip, clients would receive RFID-enabled pallets. With the PLUS ID program, clients would not have to worry about installing the technology. Similar to the pallets themselves, the clients would rent a high-quality technology that simply worked. Moreover, the PLUS ID tags would be rewriteable, enabling the clients to store information about the products loaded onto the pallet. By taking advantage of PLUS ID, clients would be able to improve their supply chain administration and improve their product management.

It was a story similar to that of Electronic Data Interchange and bar codes of the prior decade. The manufacturers needed to comply with the requirements of the retailer community. However, the uneven pace of the standards adoption forced compliance of only a limited number of their larger customers, a circumstance that demanded their investment in infrastructure. For their part, Wal-Mart, Target, and Albertsons were open to the standards and practices issues and seemed to accommodate to standards and processes that served both sides of the exchange. With the PLUS ID service on the horizon, CHEP seemed poised to offer its clients—both manufacturers and retailers—an effective approach toward aligning the strategies of the entire supply chain.

Despite the potential for higher supply chain visibility and better data analysis in the future, both manufacturers and distributors were hesitant to adopt the PLUS ID service. Given the uncertainty in the development of the technology and the final requirements of the Wal-Mart mandate, the clients tried to minimize their initial technology investment. The most common approach to deal with the Wal-Mart mandate was to simply attach single-use RFID tags to the cases and ship them to Wal-Mart. The "slap-and-ship" approach, as it was called in the industry, did not require building a reader infrastructure, which could cost up to $10.000 per portal, or integrating new middleware. The information on the tags would never be read by the manufacturers. The manufacturers did not want to invest into systems infrastructure until industry-wide standards for the technology were set.

While the CHEP solution was state of the art, a difference of 49 cents per pallet trip, which corresponds to an 8 to 10 percent price increase to the cost of a regular pallet trip, was significant to suppliers that already had lower margins than their peers that did not deal with the large retail chains. Convincing manufacturers to buy a service that promised future benefits but no immediate efficiency gains would be a hard sale to make. Moreover, the clients argued that CHEP only wanted to recoup its initial technology investment at their expense while, at the same time, reaping the benefits of the internal process improvements. CHEP, on the other hand, argued that the services would only work if all the pallets were equipped with RFID, making the investment necessary.

CHEP's RFID team faced a classical chicken-and-egg problem: CHEP could only realize the potential of RFID tags if it generated enough critical mass, both in terms of customers and revenue, to equip fully all pallets. However, clients were not able to make investments before the technology was proven, the infrastructure was in place, or before the benefits of the system could be realized. Beattie knew that the PLUS ID Service would only be the beginning of a variety of value-added services as long as he could convince a few customers to carry the burden of the infrastructure investment. Was it really too far-fetched trying to transform the company known for providing blue pallets into a trusted logistics partner that adds value across the supply chain as a whole?

PART B: CHEP: Tracking the Progress

Introduction

By the end of 2003, CHEP made the decision to proceed with its RFID development. While a pool of RFID-enabled pallets would bring benefits both to their internal operations and to their customers, it was clear that further investment would have to come from outside of CHEP. With the initial deadline of January 2005 fast approaching, there was hope that that the Wal-Mart mandate would increase demand for the RFID-enabled pallets, tagging the complete pallet pool as a by product of the retail giant's pressure. At the same time, Beattie and Sawhney understood that they would have to quantify the both the network and the individual benefits for CHEP's customers in order to receive the infrastructure investments and to secure long-term contracts for the RFID-enabled pallets.

Extended Pilots

In order to better communicate the benefits of RFID in the supply chain, Sawhney decided to conduct broader research on RFID studies and to set up use cases with selected partners. First he gathered information on key benefits from previous studies. A study conducted by IBM showed that an RFID-enabled supply chain could lead to 7- 20 percent increase in labor efficiency. Studies by the Auto ID center found similar results in efficiency (3-12 percent), and also concluded that inventory cost of losses, maintenance and item returns could be reduced in the 10 and 20 percent range. While those numbers where promising indicators, the CHEP team realized that they would have to show that their own technological solution could provide similar, if not better, results for its clients. Thus, a new pilot study that reached across different supply chain links was designed.

Having learned from the experiences of the internal pilot the team decided on a different set up for the pilot in late 2004. First, they decided that this time around selected partners would have to partake in the pilot to share the costs as well as to increase the credibility of the project. Specifically two major manufacturers and a large retail chain in the Brazilian market decided to support the project. Moreover, the experiment was significantly narrower in scope and smaller in size, with only 1000 tagged pallet moving between the 13 distribution centers of CHEP, the manufacturers and the distributor.

Focusing mainly on the areas of shipping and receiving and information interchange, the two month pilot provided valuable lessons and performance indicators. Most importantly, an estimate on the Return on investment (ROI) could be made: For high priced retail items such as perfumes or razors a positive ROI could be expected in the third year of operation whereas low margin dry goods would not yield a positive ROI until the ninth year of RFID-enabled operation. Moreover, the experiment convinced both manufacturers to enter into long-term contracts with CHEP USA by 2006, both sharing the cost of the tagging and paying premium prices for the use of 10,000 RFID-enabled pallets per month.

Wal-Mart RFID Mandate and Collaboration

Equipped with the positive results and the announcement of the two manufactures the CHEP team was confident that more customers would agree to use RFID-enabled CHEP pallets. However, Wal-Mart delayed the deadline for its mandate several times, reducing the pressure on its suppliers to adopt RFID-enabled solutions. Moreover, after experimenting in their five Texas distribution centers for several years, Wal-Mart recognized in late 2006 that for their purposes the RFID enablement of the stores should take priority over the use within the whole supply chain. An executive stated that out of stock products had already dropped by 30 percent and the efficiency of moving products from the backroom to shelf had increased by 60 percent. Thus the focus on the RFID mandate shifted from delivering store information to the suppliers rather then optimizing the supply chain.

Despite the setbacks, CHEP further intensified its collaboration with Wal-Mart. In 2007, CHEP agreed to provide its pallets free of charge to Wal-Mart, as an attempt to convince affiliated manufacturers to use (and pay for) CHEP pallets. Further, CHEP became an integral part of Wal-Mart's green packaging initiative, an effort to reduce waste associated with the packaging process. Wal-Mart, promoted the CHEP pooling model as the most environmentally friendly packaging alternative.

Innovation and Competition

The success of CHEP's pooling model did not go unnoticed. Several competitors created businesses models that where strikingly similar to CHEP. While companies such as IGPS where unable to compete with both the size and the network density of CHEP's pallet pool, they would challenge CHEP with new innovative products and services. IGPS developed a plastic pallet that was 30 percent lighter and was projected to last 10 to 20 years longer than CHEP's wooden counterpart. Being led by a former CHEP executive and having a smaller pallet pool, IGPS had the foresight to equip all pallets with four RFID tags. Yet, only in late 2006 IGPS announced pilots to test the technology, lagging behind CHEP by nearly three years. Also, with a price point of over USD 60 per pallet, IGPS was hard fought to steadily increase its pallet pool to realize economize of scales and network effects.

CHEP reacted to the new competition by further innovating RFID technologies and by expanding the PLUS ID service beyond the wooden pallets. Realizing that its clients would be slow to adopt into RDID reader infrastructure, CHEP decided to accommodate older reader technologies that were already in place at most facilities. The result was the 3-in-1 tag that was readable by RFID readers, barcode scanners and, last but not least the human eye. The multi-mode readability enabled tracking across the entire supply chain, as long as the data was fed back into the information system. In addition, the new tags were also rewritable, allowing customers to store specific information, such as shipping date, or destination aside from the predetermined “license tag numbers” assigned by CHEP.

Looking Ahead

By 2007, selected clients had opted in to the Plus ID program. RFID pallets were shipped on an on demand basis, to customers that had agreed to pay the PLUS ID surcharge. While no exact numbers were published, it was estimated that every month between 10,000 and 20,000 RFID-enabled pallets were issued from the CHEP service center. While this was only a small portion of the pallet pool, it allowed CHEP to continuously tag new pallets, an effort that essentially was paid for by the PLUS ID revenues. It would be a long way to tagging all of CHEP’s pallets but the experiences from the pallet business were invaluable for the other lines of business.

CHEP aggressively moved into new customer segments. In late 2006 CHEP started to tag its plastic containers. Tagging its plastic containers with RFID technology enabled CHEP to further expand its pooling model to the automotive, beverage, and raw materials industries. Furthermore, CHEP also started to markets services related to the expertise gathered in the pilot studies. Named Supply Chain Consulting, a group of technology and supply chain experts offered their services to clients and external customers.

In the beginning of 2007 Beattie and Sawhney looked back at the last five years and realized how far they had come. The RFID related innovation had helped CHEP maintain market leadership in the pallet business, while at the same time fostering

CHEP's reputation as one of the most innovative companies in the supply chain business. Moreover, the spill-over effects into other industry segments and the creation of new services were seen as a good signs to manifest CHEP as a key player in the logistics industry. Although they not achieve the initial goal of tagging the complete pallet pool and having the all of its customers equipped with RFID infrastructure and corresponding data management software, they still saw a bright future for CHEP and its RFID-related business.

APPENDIX B: SKYPE SA

PART A: EBay's Acquisition of Skype SA: Valuing the Voice of the Buyer

Introduction

The early fall of 2005 was full of speculation about the future of the major Internet players Google, Yahoo, and EBay. In the constant struggle to gain market share and to extend their user bases, the three companies were looking to Internet communication service provision as a potential target for market extension. Yahoo started the reign of deals when it acquired Dialpad, a Voice-over-Internet Protocol (VOIP) communications provider, and its user base of 14 million in June 2005 for an undisclosed amount. Google soon reacted by releasing its own VOIP service, Google Talk, in late August.

While it was expected that the two leading Internet portals would make a move toward acquiring VOIP capabilities, it came as a surprise when EBay, the world's leading online marketplace, announced plans to purchase Skype SA, a European VOIP provider in September 2005. The deal, potentially worth more than USD 4 billion, was rationalized with synergies between EBay's business lines and as an acquisition of a user growth engine. Although EBay had been successful in the past with integrating of new businesses such as PayPal, many outside observers had doubts whether the acquisition of an unrelated business was a wise business decision:

Brief History of VOIP and the IP Telephony Market

Internet Protocol telephony (IP telephony), or voice over IP (VOIP), referred to voice calls that were transmitted over an IP network such as the Internet, rather than over the familiar circuit switched telephone network (PSTN). In a PSTN, telephone calls were routed based on a destination number and the geographical location of the called user. Thus, in a circuit switched network, first a connection was established before a call can begin. The topology of the telephone operator owned network dictated how calls are routed.

In the IP process, data were packetized, sent to a specific IP address and then reassembled at the destination. Packets were routed and rerouted through network hosts without a predetermined route until they arrived at the destination. Thus, no given package had to take the same route or to use the same network as the other associated packets. As such, IP-based communication did not require a proprietary infrastructure. However, since IP was a connectionless protocol, data corruptions, out-of-order delivery of the packets, or lost packets were common occurrences. While those effects could be mitigated through transmission of redundant packets, it provided challenges for the time critical delivery of voice data.

IP telephony evolved parallel to the Internet. In the late 1970s, experiments to transmit voice over ARPANET, the predecessor of the Internet, were undertaken. While these experiments demonstrated the capabilities of IP telephony, only some of the few individuals with access to ARPANET used these applications. The end user adoption of the WWW, fueled by the availability of the Netscape browser in 1995, led to the development of commercial VOIP applications.

Early Commercialization

Released in March 1995, VocalTec's InternetPhone was one of the first VOIP software applications available to the public. Priced at USD 49.99 for two licenses, the software allowed free PC-to-PC calls between users who had installed the software client. The application included features such as a user-friendly interface, chat capabilities, collaboration tools such as white boards, and a directory of users online (Keating 1996).

While the client was quite sophisticated for its time, there were several technical hurdles that prevented mainstream adoption of the InternetPhone application and IP telephony in general. First, VOIP required high bandwidth to achieve satisfactory sound quality. At the time, most end users connected to their Internet Service provider via 14.4 or 28.8 Kbit modems. The most common approach to counter the bandwidth restrictions was to compress the packets. However, the early compression standards required processing power that most PCs could not provide at the time. Moreover, the lack of standard interfaces for auxiliary devices such as soundcards, more often than not led to compatibility issues.

The result of these early hurdles was a subpar user experience. The lack of bandwidth and processing power led to delays in the transmission and lost packages. Most of the time, only one user could speak; pauses during the conversation were the norm. However, despite the low quality of service, certain applications, such as overseas calling led to adoption. One early adopter summarized his IP telephony experience in 1996:

VocalTech (Internet Phone) and maybe half a dozen other outfits are offering phone-like service over the Internet. Right now it's a bit like ham radio. But it's very intelligible and very usable as a social medium and even for business. Which am I going to opt for—the kind of quality that lets me hear a pin fall in the background for about $100 an hour to talk to someone in Europe, or just enough quality at no charge beyond what I pay my Internet access carrier (about 30 cents an hour). (Seltzer 1996)

In the fall of 1996, a major step toward improving the quality of IP communications was undertaken. At that time, the ITU-I, telecommunications standardization sector sanctioned by the United Nations, approved the H.323 standard as the international standard for multimedia communications over packet-based networks. The standard adoption had three major outcomes. First, it minimized hardware configuration issues that had slowed adoption of VOIP services in the past. Second, the unified standard allowed connections between the formerly separate software clients, increasing the network of users that could call each other. Third, and most importantly, H.323 also provided a gateway to the PSTN network, allowing for PC to landline calls.

Net2Phone, a subsidiary of calling card giant ITD, was one of the first companies to take advantage of the new standard. In 1997, it added PC-to-Phone to its existing PC-to PC service. By 1999, Net2Phone was the clear market leader in the VOIP market, claiming 1.5 million registered users. Despite being unprofitable at the time, the company received investments by Softbank and AOL. The initial public offering in July raised USD 80 million for 12 percent of its shares followed by the sale of an equal share for USD 384 million just five months later. Despite its success with the capital markets, Net2Phone never managed to live up to its promises. 2003 was the first profitable year for Net2Phone. By then the market capitalization had dropped to less than 5 percent of its initial value [.

Several factors led to the demise of Net2Phone. From a market perspective, the Internet bubble had burst and investors were shying away from unprofitable companies. More importantly, users never switched to making VOIP calls, despite the potential cost savings. From a user perspective, calling from the PC was still inconvenient. Starting up the PC, plugging in the microphone and dealing with an unaccustomed user interface, did not lend itself to making a quick phone call [Wong 2003]. Moreover, broadband Internet, a major factor in VOIP quality, was only starting to be adopted in U.S. households.

By 2003, the VOIP market in the U.S. was highly segmented. There were numerous niche providers of PC-to-PC services that allowed their users to call each other. Also, MSN and Yahoo had equipped their Instant Messengers with voice capabilities. However, there was still a lack of interoperability between networks, leading to the inconvenience of having to use multiple clients to reach various contacts. In the PC-to-Phone segment, Vonage had become the new market leader. The Vonage service was marketed as a landline replacement, by offering hardware that would work independently of a software client and that could utilize existing telephones. However, pricing similar to existing PSTN contracts and the varying call quality led only to modest adoption. By 2003, only 150,000 paying Vonage subscribers were active.

Skype SA

Skype SA was the brainchild and second startup of Niklas Zennström and Janus Friis. Rather than focusing on a specific market, they focused on the possibilities of peer-to-peer (P2P) technology. In 2004, Zennström recollected (Oakes 2004): *"When Janus and I started [...] our vision was that peer-to-peer technology was kind of a fundamental technology that could be used for a whole lot of different business areas."*

Their first venture was Kazaa. After the legally induced demise of Napster for providing a centralized database that listed the locations of copyrighted files, Kazaa soon became the peer-to-peer (P2P) file-sharing network of choice. It gained popularity since it was completely decentralized and outside the reach of U.S. authorities, being headquartered in the Netherlands. Much like Napster, it enabled its users to search, share, and trade digital assets such as documents, music, and movies. By the fall of 2001, Kazaa had more than 5 million users.

Kazaa did not earn money from the actual trades but by bundling its client software with Adware and Spyware such as Cydoor or Webhancer (Cave 2001). Yet the music industry argued that Kazaa indirectly profited from the infringement committed by its users and sued Kazaa. Under tremendous legal pressure and with costs mounting, Zennström and Friis knew they had to move on. In January 2002 the pair sold Kazaa for $500,000 to Sharman Networks, a company incorporated in Vanuatu in the South Pacific.

"To make it work, we would have had to be very savvy about the music business, and that was not our strength," says Zennström. "So we thought, 'Let's try the next incarnation of this' (Foroohar and McGinn 2005)." The lessons from the Kazaa experience were clear: To turn their deep knowledge of P2P technology into a commercially successful venture, they needed to have a clear-cut revenue model that would steer clear of legal trouble.

In the summer of 2002, the two decided to tackle the USD 1 billion communications industry. They formed the ambitious goal of providing a free and easy-to-use application that would enable users to have free telephone conversations over the Internet, eventually replacing landline phones. Being backed by small venture capital investments and supported by the same programming group that aided them to create Kazaa, they started their new venture in a small office in Luxembourg.

Within a year, the first beta version of their software was launched, enabling PC-to-PC telephony. Radically different from the traditional telecommunication companies, Skype incurred hardly any infrastructure-related fixed costs. By using VOIP, they utilized the free Internet infrastructure, and by deploying P2P distribution, they used the idle computing resources of their users rather than their own expensive servers.

The first beta version was launched in 2003, enabling only PC-to-PC telephony. Less than two months after the release of the first beta version, more than 1.5 million users had downloaded the Skype application. Within a year, this number had risen by over 100 million with more than 1.2 billion PC-to-PC voice minutes served.

More importantly, in July 2004, Skype finally started to generate revenue by introducing the paid-for PC-to-Phone service branded SkypeOut. Priced between USD .02 per minute, for calls to landlines in mature telecommunication markets, to USD 1.46 per minute per minute to calls to East Timor, more than 2 million SkypeOut calls were undertaken in the first month alone (Zennström 2006). By March 2005, more than 1 million customers had purchased and used SkypeOut. In June 2005, Skype added two more premium services: SkypeIn (a virtual local number that enables landline users to call the Skype user) and Voicemail. The second anniversary of the initial product launch revealed staggering numbers (2005b):

- More than 150 million downloads in 225 countries and territories
- More than 51 million people registered users (150,000 new users per day)
- More than 12 billion minutes served (equating to more than 45 percent of all U.S. VOIP traffic)
- More than 2 million people created accounts for Skype's paid services

Besides its core business, Skype also developed a vast network of thousands of partners and developers building hardware and software products, as well services around the Skype experience.

At the time of the acquisition Skype was still an unprofitable business. Revenue had increased from an estimated USD 7 million in the first year to nearly USD 60 million in the fiscal year of 2005. Gross margin was estimated at about 18 percent of the revenues, mainly due to the high cost of the landline connection fees (Blodget 2007a). However, Skype had managed to develop a successful product and become the VOIP market leader in the course of two years, using only USD 35 million in venture capital. It did not take long for the traditional telecommunication companies and other interested players to notice this exponential growth fueled by viral marketing of a great product.

Ebay Inc.

Founded in 1995, Ebay Inc. had become a global powerhouse of online marketplaces, acting as a broker to facilitate transactions between buyers and sellers across a wide range of goods and services. What began as an auction site for collectibles has developed into a wide spectrum of possibilities across virtually every product category imaginable.

In 2005, the two pillars of EBay's business were the EBay marketplace and the PayPal payments unit. The EBay management described its role in the marketplace as that of a "trading platform":

[EBay] marketplace exists as an online trading platform that enables a global community of buyers and sellers to interact and trade with one another. Our role is to create, maintain, and expand the functionality, safety, ease-of-use, and reliability of our trading platform while, at the same time, supporting the growth and success of our community of users. (Ebay Inc. 2005)

The EBay platform included software tools and services that allowed buyers and sellers to trade with one another more easily and more efficiently. Software tools and services helped automating the selling process and aided in the shipment process. Moreover, PayPal facilitated the online exchange of funds and provides fraud protection.

Aside from internal improvements driven by its vast community, EBay has relied on external partnerships and acquisitions both to improve the transaction experience and to increase its share of transaction fees. Services such as the global payments platform, trust and safety programs, user verification, buyer protection and assurance programs, postage and other shipping services, vehicle inspections, escrow, and authentication and appraisal services were intended to create a faster, easier, and safer trading environment.

Business Model and Investment Strategy

Meg Whitman, the CEO of Ebay Inc. at the time of the acquisition, had long held the notion that EBay's core competence was the connection of buyers and sellers (Benkler 2006). The marketplace initially connected parties in an auction format for used or overstocked items. With EBay Express, sellers and buyers of new items were connected. In the same vein, PayPal provided a platform where parties can facilitate transactions, regardless of their actual bank accounts or preferred currency.

PayPal, acquired in 2002 for USD 1.5 billion, was both the most expensive and most influential of EBay's investments. At the time of purchase in July 2002, PayPal account holders numbered 16 million, with 295,000 payment transactions taking place every day. Moreover, an estimated 25-to-40 percent of transactions taking place on EBay were settled through PayPal (Kane 2002). By the end of 2004, PayPal had become an integral EBay business model, contributing nearly 20 percent of total net revenue and posting more than one-third of its 64 million accounts as active.

Although EBay was the preeminent auction site on the Web, EBay had extended its business model beyond market matching and transaction facilitation. By 2005, EBay had also made numerous investments in the sales-lead business, such its 25 percent ownership of craigslist.com (a free classified site), the acquisition of Shopping.com (price comparison portal), and Rent.com. While the EBay portfolio seems diversified, all investments were targeted to either create sales leads prior to a transaction (shopping.com) or to remove friction from the transaction (PayPal), which aimed to strengthen the core business of the marketplace by increasing the volume of transactions, by growing the revenue share of the conducted transactions, and by making transactions more efficient and convenient.

While those investments showed promise to grow EBay in the long run, it also became clear that EBay needed to find more innovative and disruptive technology to continue the streak of growing net revenue at nearly 50 percent annually.

The Acquisition of Skype

In 2005, the VOIP industry became the target of heavy private investment and takeover speculation. Fueled by the market penetration of broadband Internet, Vonage Inc. had surpassed the 1 million subscriber mark by early September and had secured more than USD 600 million in private funding. Yahoo Inc. also invested in the VOIP business, buying Dialpad and its 14 million customer base for an undisclosed amount.

Moreover, Google refrained from buying an external provider, instead introducing GoogleTalk in late August.

Skype SA was rumored to be a target for all the aforementioned companies (Kewney 2005). The potential suitors viewed acquisition of Skype SA as a preventative move which would certainly hurt the companies that failed to buy the VOIP market leader. However, Zennström did not simply want to sell Skype and see the company dismantled by its suitor. He favored a solution where Skype would be acquired but could still operate as a stand-alone company:

You've seen it so many times when technology companies are acquiring small companies and one year after you don't see those companies anymore because they got completely dismantled. This happens like when Cisco, or Microsoft or some other company is acquiring companies. We said Skype needed to be a separate company so that you can still foster the growth and the innovation of the company but we should take advantage of synergies when we have them. (Steinberg 2006)

When EBay approached Skype SA, Zennström saw the chance to fulfill his vision, drawing parallels to PayPal. PayPal had developed into the premier payment-processing provider by utilizing both the EBay marketplace transactions and developing its merchant services for independent e-commerce merchants. Thus, PayPal had the best of both worlds: It leveraged EBay's platform to grow its network, which in turn made it more attractive for merchants to adopt PayPal payment processing.

EBay's management also was intrigued by the striking similarities. Just like EBay and PayPal in their early days, Skype posted tremendous growth numbers fueled by viral marketing and the concurrent network effect. Moreover, Skype was already the market leader in VOIP communication service provisions, and its paid services were just starting to take off. Thus, the business would be able to sustain itself without further subsidies. In addition to being a successful stand-alone business, EBay could also foresee vital synergies if the acquisition occurred. Skype could augment EBay in two dimensions: volume and network effects across the subsidiaries.

Two key areas were expected to increase EBay's transaction volume: the increased user base and the establishment of lucrative high-priced auctions. Skype had a user base that was strikingly complementary. With 84 percent of Skype users registered outside the U.S. and, according to Nielsen NetRatings, with an only 1 percent overlap of Ebay U.S. and Skype users, there was a ready-made customer network of 50 million potential Ebay users that was growing by 150,000 every day. Besides the European contingent, Skype users were mainly located in fast-growing economies such as India, China, and Russia where EBay or any other online marketplace had yet to become a dominant force. Through Skype, the penetration in those markets could be accelerated. In addition, EBay also envisioned that live or open-cry auctions would be enabled through the Skype voice and one-to-many video conferencing technology. In the same vein, it was anticipated that high price and communication intensive categories such as art and antiques would increase.

Second, Skype's integration was anticipated to foster cross-marketing among the different EBay brands. The management envisioned that Skype could be integrated into EBay auctions to facilitate more intimate communications. Moreover, with PayPal already accounting for roughly 20 percent of Skype's transaction processing, a money-wire per call or integrated paid-call service model was easy to conceive. Lastly, the Skype integration also was seen as vital to strengthening the sales-lead and classified business.

Ebay proceeded with the acquisition process by offering a two tiered deal that was accepted by the Skype SA shareholders in October 2007. The first part of the offer included an immediate purchase price of USD 2.6 billion, payable in EBay stocks. In addition, a performance based earn-out was negotiated. If Skype would achieve undisclosed performance metrics over the next four years, the Skype owners could receive an additional USD 1.7 billion. Moreover, key Skype personal had to commit to work for the newly formed EBay subsidiary for the next few years.

In an investor conference call following the acquisition announcement, EBay's CEO at the time, Meg Whitman, summarized that:

Communications is at the heart of e-commerce and community. By combining the two leading e-commerce franchises, EBay and PayPal, with the leader in Internet voice communications, we will create an extraordinarily powerful environment for business on the Net (Neilan and Belson 2005). *[which will deliver] unparalleled e-commerce and communications engine [by] removing a key point of friction between buyers and sellers.* (Broache 2005)

While Whitman's predictions were enthusiastic, the market voiced a more skeptical opinion.

Reactions to the Acquisition

The reactions to the acquisitions were mixed at best. In the week after the announcement, EBay shares fell nearly 4 percent (2005a). Besides the heavy price tag of USD 2.6 billion (plus a potential USD 1.7 billion in performance earn-outs), the distancing from the core business was the main concern voiced by analysts and industry experts.

Industry observers were quick to observe that most of the previous investments were led by the needs and feedback of the users (Hof 2005). One reason to purchase PayPal, despite the previous USD 100 million investments in BidPay, was its user acceptance. Powersellers voiced their concern that Skype neither added to existing capabilities nor would change the way they conduct business on Ebay(Berr 2005). John Hagel went as far as questioning EBay's core business by proclaiming that Skype was just another high-multiple purchase that would divert from the marketplace's slowing growth and saturation, resembling purchases undertaken at the height of the Internet bubble. He further doubted whether a partnership would have been a cheaper and more reasonable alternative to the acquisition (Hagel 2005).

While the synergy and network effects were generally dismissed, support of the acquisition persisted. Martin Geddes, a telecommunications analyst, noted that it was simply an attack at another industry that generated huge revenues while lacking to innovate:

Just like PayPal was a business model that disrupted the banking industry, the acquisition of Skype is EBay's attempt to take its slice out of the telecommunications companies' revenues using an innovative technology. (Geddes 2005)

PART B: The Aftermath of the Acquisition

Introduction

October 2007 marked both the fourth anniversary of the release of Skype's first public beta and the second anniversary of EBay's acquisition of Skype SA. It also was a month of change and reassessment of the progress of the Skype integrations as the third pillar of EBay's business model.

The month started out with the announcement that co-founder Niklas Zennström would leave EBay to focus on his newest startup, Joost, and his venture capital company, Atomico. On the same day, EBay also announced that the Skype shareholders would receive USD 530 million in earn-outs, which was roughly one-third of the maximum payout of USD 1.7 billon that was negotiated during the Skype acquisition two years earlier.

Later that month, EBay also reported its third-quarter earnings, which showed growth in Skype's revenue and user base as well as profitability for the third straight quarter. The month was capped with announcements of Skype's final integration into all categories of the EBay marketplace, an integration of Skype into MySpace, and an integration of Facebook content into the Skype client. Yet, despite the growing success of Skype, EBay also announced a goodwill write-off of USD 900 million, which decreased Skype's book value to USD 2.2 billion and led to EBay posting the first unprofitable quarter in more than eight years.

Were the pessimistic predictions that many industry observers voiced two years earlier coming true?

Zennström Resigns As CEO Of Skype

As with most serial entrepreneurs, it was expected that Zennström would leave EBay at some point in time. While the original earn-out period was scheduled for four years, Zennström had more interest in pursuing his newest venture. He envisioned changing TV distribution the same way Skype had changed the telecommunications industry. Thus, IPTV became the new focus. Simply put, leveraging the P2P distribution to provide Internet Television on steroids. The name of the fledgling company was appropriate: *Joost* (pronounced "juiced").

In fact, the announcement of his departure coincided with the public release of the Joost Beta version. While most of the industry observers equated the smaller earn-out as a sign of Skype failing to meet its growth and revenue expectations, it was nothing short of remarkable to have sold a company for more than USD 3.2 billion after only four years of market presence. Co-founder Janus Friis put the "failure" in perspective:

> *Earn-outs are inherently difficult creatures, but we are happy with the result of this one. We are approximately half way into the earn-out period and the settlement amounts to one-third of the total possible earn-out amount*. (Friis 2007b)

Despite the fact that the lofty expectations toward Skype's performance were not met, the growth in revenue and user base was still remarkable. Since its acquisition two years earlier, Skype had nearly quintupled its registered user base to over 240 million. Also, revenue for the fiscal year of 2007 was expected to exceed USD 400 million, which was an increase of more than 650 percent compared to the year of the acquisition (Schonfeld 2007). In addition, Skype had managed to become profitable for every quarter in 2007 (Ebay Inc. 2007). The EBay management was quick to add that Zennström move to the position of non-executive chairman of Skype would not change the long-term strategy of the subsidiary (Musich 2007).

Growing Skype As A Stand-Alone Business

In its two years as an EBay subsidiary, Skype management had focused key drivers for growing its user base: further accelerating the viral adoption of the client and continuously releasing new software clients to adapt to the users' evolving needs.

Accelerating the Viral Growth

On a global scale, Skype continued the exponential growth of its user base. Since the acquisition, the number of registered users increased from 50 million to nearly 250 million. The growth was mainly attributed to the viral power of Skype. Yet, on a regional basis, Skype adoption varied. While Europe and Asia posted strong growth rates, the U.S. was lagging behind. To increase the popularity of Skype in North America, the company offered free SkypeOut calls within the U.S. and Canada from spring 2006 until the end of the year. Yet, as SkypeOut minutes increased by 40 percent over that time span, the revenue share of U.S. users did not rise during the promotional period or in the first three quarters of 2007.

Enhancing the Software Client

The second driver of user growth involved introducing new features and fostering innovation of complementary hardware accessories. With Version 2.0, released in December 2005, Skype introduced video conferencing. Initially only employed for one-to-one calls, the feature evolved, creating the new capacity for one-to-many SkypeCasts. In May 2006, Skype 2.5 enhanced this feature enabling many-to-many video calls, thus evolving into a cheap alternative for global videoconferences. This version also incorporated SMS for as little as USD .01 as an attempt to tap into the USD 40 billon text messaging market (2008a). Skype 2.5 also introduced better usability features such as the automated import of email contacts and categorization of contacts into groups.

Staying on pace to release an overhauled version every six months, the Beta version of 3.0 became available in November 2006. Most of the features, such as personalization of the client and design overhauls, were usability-oriented. To further foster SkypeOut calls, 3.0 also included browser integration by offering its "click to call feature," which recognized phone numbers displayed on Web pages, automatically converting them into a direct link that would launch a SkypeOut call upon a click. The latest version was geared towards features that would mimic modern telephone systems.

Version 3.5 included features such as call transfer, automatic redial, and the integration into MS Outlook, all clearly targeted at business users.

Setbacks of Growth and Continuous Innovation

The growing popularity also had negative effects. In September 2007, a software worm spread quickly through the Skype network, raising Skype-related security concerns and causing many systems administrators to temporality block Skype traffic. While the worm did not cause any harm, it was a reminder that Skype had to address security to cater to business clients. This was particularly important after a Skype service outage a month earlier caused severe criticism of how the situation was handled and raised the question of whether Skype really was a reliable landline replacement (Blodget 2007b).

Despite the setbacks, the new features were embraced by the user community. On average, half a million clients were downloaded every day, amounting to more than 700 million total downloads of the different Skype clients by the end of October 2007. At the same time, Skype also was able to eclipse the mark of 10 million concurrent users, increasing by tenfold the 1 million concurrent users it had only three years earlier (Mercier 2007).

An EBay spokesperson summarized Skype's performance: "We feel like we can do a lot more with Skype as a stand-alone VoIP provider. Skype has been focused on user acquisition and it's done a great job. But we also feel like we can find new ways to monetize those users" (Reardon 2007).

Growing the Revenue

Soon after the 2006 promotional period of free SkypeOut calls in North America ended, Skype introduced a new pricing structure and features to grow the VOIP revenue per user. In January 2007, Skype changed the SkypeOut pricing structure by adding a connection fee of USD .045 for every call placed. At the same time, it also offered SkypePro, which included a lower per-call fee and discounted fees on features such as SkypeIn and voicemail, but required a monthly subscription fee of USD 3. There were a few outcries about the changing pricing structure, but despite the expected drop-off from users who only used SkypeOut while it was free, paid voice minutes grew proportionally to the number of users added (Friis 2007a). However, in fall 2007, evidence emerged showing that the usage of SkypeOut was declining. Despite the continuous growth of the user base, the total number of SkypeOut minutes had stagnated at 1.4 billons in each quarter in 2007. One industry analyst noted that" Skype's core business isn't much different from a really cheap calling card business. The margins are really thin" (Reardon 2007).

To diversify revenue streams, Skype introduced other telephony services and pricing packages. SkypeUnlimited was offered as a flat rate for in-country calls for a monthly flat fee of USD 3. SkypeFind, a directory listing service, was introduced as a platform for premium calls that were usually associated with 0900 numbers. SkypePrime enabled service providers to set their own price for offerings such as consulting that could be conducted via the Skype client. In addition to internal developments, Skype actively promoted third-party services and products in an effort to further increase the paid voice and licensing revenues.

From a financial perspective, Skype slowly picked up steam. The first three quarters of 2007 were all profitable. The revenue had steadily grown and was expected to be close to USD 400 million in the 2007 fiscal year. However, there were also signs that the monetization per user did not seem to increase. On average, every registered user had only generated approximately USD .40 per quarter since 2006. Also, not only did the volume of paid SkypeOut minutes stay flat in 2007, the actual number of free Skype-to-Skype minutes actually declined, raising concerns that after the initial hype, more and more power users were switching to competitive services.

Integration Efforts

Synergies with the other EBay business lines were the main justification for the acquisition of Skype. The effort was dubbed “The Power of Three,” indicating that three stand-alone growth businesses could be even more successful if they were integrated across the three businesses. The first integration took place between Skype and Paypal. Touted as a VOIP-enabled “Western Union,” Skype’s version 2.5, released in May 2006, was expected to include functionalities to send and receive payments from contacts with a click of a button. Yet, the feature did not appear until March 2007, raising questions as to why the integration of the already preferred payment provider was taking so long.

The same criticism was voiced over the integration of Skype into the EBay marketplace. Although the Dutch EBay subsidiary marktplaats.nl started a pilot integration in October 2005, EBay was slow to introduce Skype on a global scale (2005c). After pilots in other European countries, the SkypeMe button, allowing instant calls to the sellers, was first rolled out in selected U.S. categories in June 2006. EBay justified its slow roll out as an adoption experiment citing that it did not want to confuse its sellers with unfamiliar features. Yet the resistance of sellers to use voice features in general seemed also to have played an important role in the decision (Hof 2006). In fall 2007, Skype finally was integrated into all EBay categories. In the process, EBay also banned all other voice services from its site, stating that only EBay-owned Skype could be used to facilitate marketplace-related voice communication (Steiner 2007).

It was unclear what the results of the delayed integration would be. But it was apparent that EBay was dissatisfied with the slow progress and lack of monetization of synergies. As a result, Ebay took a goodwill write-down and reduced the book value of Skype to USD 2.2 billion. In an effort to revamp the efforts to grow the synergies, most of the Skype management was replaced alongside Niklas' departure (Associated Press 2007). While internal synergies had yet to materialize, partnerships with third-party providers were starting to flourish.

Third-Party Applications and Accessories

On the accessory side, innovations received an enormous amount of publicity. The announcements of the release of WIFI-enabled phones by Netgear and Keyspad were among the biggest Skype-related news items of 2006 (2007). The release of the 3G/ WIFI hybrid Amobi Phone in Europe was an instant sellout. Priced at 100 USD, the phone enabled customers of Hutchinson's subsidiary 3 UK to take advantage of modest Skype pricing while being within the coverage of a WIFI hotspot. Besides the revenue from the SkypeOut calls, Skype also was expected to receive a share of the regular phone usage and licensing fees.

Moreover, a large-scale roll out of Skype branded accessories at Wal-Mart was announced in the summer of 2007. While specifics of the deal were not disclosed, it was estimated that Skype commanded a licensing fee of 5 percent of the wholesale price for Skype branded or Skype certified hardware products. In addition, prepaid calling cards allowing unlimited PC to landline calls in the North America for USD 8.85 were offered. While the financial gains had yet to materialize, it was assumed that the exposure to Wal-Mart's large distribution network would open up new customer segments that would use Skype's paid services rather than just the free services offered by Skype.

Aside from the efforts to increase the monetization of its users, Skype also pushed to expand its range of services. Originally developed as a closed application with a proprietary protocol, the Skype client soon evolved into a programming platform. In 2005, the Skype Developer Zone opened to the public, allowing programmers to develop applications and features by themselves. Available documentation and frequent developer competition attracted a wealth of volunteer developers. In the three years of its existence, the "Skype sandbox" had much to show. More than 4,000 developers participated, creating more than 350 Skype-enabled applications (Willis 2007).

In fall 2007, Skype announced collaborations with the popular social networking sites Facebook and MySpace. On one hand, Skype integrated popular Facebook games into its clients, giving users the chance to play with their friends while using Skype. Skype also started to develop games of its own, which it then planned to publish via Facebook. Facebook games had become a hot trend, with users challenging their friends on a daily basis. Skype wanted to leverage that phenomenon for two reasons: to raise the awareness of Skype by displaying its brand name within the games and to put an application launcher onto the Facebook profile of each user that had added the game (Dolcourt 2007).

The MySpace announcement was less subtle. On October 16, 2007, Skype became the official voice provider for the network of 110 million MySpace members. Skype was to be incorporated into the MySpace Instant Messaging client, enabling MySpace users to place free Skype calls to their friends and eventually adopt Skype as their VOIP client of choice for paid services, as well (AFP 2007).

Both efforts were deemed as another attempt to leverage viral effects in social networks and to introduce Skype to a younger and predominantly North American audience. However, given the track record of Skype’s integration into the EBay marketplace, it seemed doubtful that the announced partnerships would materialize any time soon.

Looking into the Future

Skype had gone through a tremendous development in growing its user base, but two years after the acquisition it was challenged to monetize that growth. Several industry observers suggested that Skype's future was in the mobile business, where it could offer competitive rates while earning revenues by licensing its brand name to OEM manufacturers.

In the Internet arena, Skype was facing a VOIP market with continuously eroding margins spurred by new competitive offerings nearly every week. Aside from the established players like Yahoo! Voice, GoogleTalk, and Microsoft's LiveMessenger, upstarts like JahJah and QQ, along with more than 150 VOIP providers, were fighting to lure customers (2008b; Uberti 2007). With a user base of 250 million, Skype was confident that the client would soon be synonymous with VOIP communication, evolving into a de facto standard. However, the lack of interoperability with the other networks was a concern for industry observers.

Another question was whether Skype could capitalize on the growing advertising business. While EBay initially only foresaw integration of its own businesses, there didn't seem to be a good reason why ads should not be served through the client. Yet, it appeared that EBay lacked the capabilities to place context-related ads and was reluctant to partner with competitors Google or Yahoo! to make this business line a success.

As for the integration with the other EBay businesses, the predictions were not really clear. EBay's recent foray into social commerce by creating more social network communities around specific categories did not seem to directly involve the Skype application. But then again, maybe lowering expectations might be a good strategy this time around…

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