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Towards a Service-Oriented Enterprise: The Design of a Cloud Business Integration Platform in a Medium-Sized Manufacturing Enterprise

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TOWARDS A SERVICE-ORIENTED ENTERPRISE:
THE DESIGN OF A CLOUD BUSINESS INTEGRATION PLATFORM
IN A MEDIUM-SIZED MANUFACTURING ENTERPRISE

Paul J. Stamas
Syracuse University, 2013

This case study research followed the two-year transition of a medium-sized manufacturing firm towards a service-oriented enterprise. A service-oriented enterprise is an emerging architecture of the firm that leverages the paradigm of services computing to integrate the capabilities of the firm with the complementary competencies of business partners to offer customers with value-added products and services. Design science research in information systems was employed to pursue the primary design of a cloud business integration platform to enable the secondary design of multi-enterprise business processes to enable the dynamic and effective integration of business partner capabilities with those of the enterprise. The results from the study received industry acclaim for the designed solutions innovativeness and business results in the case study environment. The research makes contributions to the IT practitioner and scholarly knowledge base by providing insight into key constructs associated with service-oriented design and deployment of a cloud enterprise architecture and cloud intermediation model to achieve business results. The study demonstrated how an outside-in service-oriented architecture adoption pattern and cloud computing model enabled a medium-sized manufacturing enterprise to focus on a comprehensive approach to business partner integration and collaboration. The cloud integration platform has enabled a range of secondary designs that leveraged business services to orchestrate inter-enterprise business processes for choreography into service systems and networks for the purposes of value creation. The study results demonstrated enhanced levels of business process agility enabled by the cloud platform leading to secondary designs of transactional, differentiated, innovative, and improvisational business processes. The study provides a foundation for future scholarly research on the role of cloud integration platforms in enterprise computing and the increased importance of service-oriented secondary designs to exploit cloud platforms for sustained business performance.

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in a Medium-Sized Manufacturing Enterprise

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CHAPTER 1

INTRODUCTION

1.0 Doctoral Thesis Overview and Organization

This body of work ("Thesis") is a presentation of scholarly research conducted in fulfillment of the requirements for a doctorate of professional studies in Information Management at the Syracuse University School of Information Studies (iSchool).

The study was conducted under the advisement of a doctoral committee represented by Dr. Scott A. Bernard (Chair), Dr. Michelle L. Kaarst-Brown, and Mr. Eric A. Marks. Dr. Bernard is a Professor of Practice at the iSchool, an expert on enterprise architecture, and currently serves as the U.S. Federal Chief Architect at the Office of Management and Budget (OMB) within the Executive Office of the President. Dr. Kaarst-Brown is an Associate Professor at the iSchool and Director of the Executive Doctorate program. Mr. Eric Marks is an adjunct professor at the iSchool, has authored numerous books on the topics of Service-Oriented Architecture (SOA) and Cloud Computing, and is currently CEO and President of AgilePath. The research study was conducted over a 24-month period commencing in April 2010 and concluding in April 2012. The research study was conducted in accordance with Syracuse University Institutional Review Board (IRB) approval number (11-092).

This case study research was conducted at this researcher's place of employment, Mohawk (formally Mohawk Fine Papers), headquartered in Cohoes, New York. This researcher has been employed by Mohawk since 2002 and currently holds the position of Chief Information Officer (CIO) and Vice President of Information Technology. This researcher reports to the President of the company and manages an annual IT budget of approximately $5M and a team of five IT professionals. This researcher had control of the research studies resources and had direct influence on the studies decisions, designs and outcomes. As such, this research is classified as 'insider research' (van Heugten, 2004) or 'practitioner research' (Robson, 2002) where the researcher has a direct involvement with the research setting.

This case study research follows the two-year transition of a medium-sized manufacturing firm towards the realization of a service-oriented enterprise. A service-oriented enterprise is an emerging architecture of the enterprise that leverages services computing to integrate the internal capabilities of the enterprise with those of a network of partners to offer its customers with value-added products and services. In response to significant disruptive forces in the paper manufacturing industry, Mohawk has embarked upon a transformation of its business strategy from an internally focused product-orientation towards a service-oriented enterprise. Over the last decade, Mohawk has secured a reputation for leadership in the effective and innovative use of information technologies to deliver business value. As a result of the confluence of these contextual factors, Mohawk provides a unique case study environment to explore the emerging phenomenon of service-orientation in the business and technology domains. This single case study employs a design science research in information systems methodology to pursue the design, implementation, and evaluation of an emerging cloud-based business integration platform to achieve enhanced levels of business process agility and the transition towards a service-oriented enterprise. In this context, the study's research question is: how does a cloud-based architecture enable business process agility in a medium-sized manufacturing enterprise? The research study seeks to make meaningful contributions to both the practitioner and scholarly knowledge base of design through the demonstration of emerging constructs, models, and methods at the convergence of service-orientation and cloud computing. This case study research seeks to provide meaningful and actionable recommendations for practitioners seeking new methods and models to integrate the firm's capabilities with those of business partners and cloud service providers. The case study pursues emerging service-oriented design techniques and provides a foundation for future research at the convergence of service-oriented architecture and cloud computing.

This thesis is organized and presented in the five chapters: 1) Introduction, 2) Literature Review, 3) Research Design and Methodology, 4) Research Results and Findings, and 5) Conclusions, Discussion and Recommendations. The Introduction Chapter provides an overview of the research agenda, presents background and contextual information, and provides an explanation of the study's purpose and significance. The research question is presented in the Chapter with a summary of the research methodology to be employed to answer the study's research question. The Literature Review Chapter presents an analysis of prior scholarship related to the research question and research themes of the thesis. The Chapter commences with the business perspective of service-orientation and establishes linkages to prior scholarly works on the topics of service-orientation and business process design. Given the emergent nature of this research, an objective of the Literature Review is to define and clarify key terms and concepts to establish a conceptual framework in which the thesis can be understood and evaluated and how the research will contribute significant new understanding. The Research Design and Methodology Chapter presents the research methodology used to acquire the empirical evidence to answer the research question. In this Chapter, the selection and use of case study research and a design science research in information systems methodology is explained in the context of the literature review. The fourth Chapter summarizes and analyzes the study's empirical data and results with only minimal interpretation. The fifth and final Chapter of the thesis presents the conclusions, interpretations and recommendations that emerged from the study. In this Chapter, both theoretical and practice implications of the study are discussed to include its limitations and potential to guide future research. This thesis employs the use of illustrations, figures and tables as appropriate to enhance the clarity of the data and information presented. At the end of the thesis is an appendix section listing all citations that attribute the language, ideas, information, or material of others used in support of the research study. Also included in the appendix is a glossary of key terms and definitions used throughout this thesis document. This body of work seeks to uphold the highest levels of academic integrity in accordance with Syracuse University academic integrity policies and procedures (dated August 2011).

1.1 Research Study Background and Context

In this section, background and context is provided for this case study research. The section begins with an overview of the case study environment (Mohawk). The following section provides a summary of information technology leadership awards and recognitions received by Mohawk as context for the pursuit of the design of emerging technologies in this study. The following section provides an overview of the industry changes and forces necessitating Mohawk's business strategy transformation and the context for the organizational problem the research agenda seeks to address. The following two sections provide an overview of the business and technology strategies pursued to address the business problem, challenge, and opportunity. Section 1.2 concludes the Introduction Chapter with a summary of the study's purpose, significance, and introduces the research question and the research methodology employed to answer the question.

1.1.1 Case Study Setting (Mohawk) Overview

The focus of this case study is Mohawk, a manufacturer and distributor of premium paper products serving digital print markets in North America. Mohawk is a fourth-generation, family-owned business operating for over eighty-years with 570 employees and annual sales revenues of approximately $300M. Mohawk has manufacturing facilities in New York and Ohio with distribution centers located across the United States. Mohawk has sales offices in Asia, Europe and Latin America, and warehouse operations in the Netherlands, and services customers in over sixty countries through merchant distribution. Mohawk has historically manufactured premium paper products used in commercial printing, photo specialties and high-end direct mail. As described in more detail in this Introduction Chapter, Mohawk is responding to the rapid decline of traditional uses of premium paper products by embracing the cloud as a platform to deliver innovative products and services, and as a means to reach new markets and channels, and as a platform to establish dynamic business partnerships for the purposes of customer value creation.

1.1.2 Industry Recognition for Technology Leadership

During the last decade, Mohawk's business success has been significantly influenced by the effective selection, deployment, integration, and management of a portfolio of information technologies to support a business model based on the efficient production and delivery of paper products. Mohawk has received numerous industry awards and recognitions for leadership in the use of information technology to achieve business objectives. In each of the last four years (2008 - 2011), Mohawk received the Progressive Manufacturing Award which recognizes the top 100 manufacturing enterprises from around the world that have achieved significant breakthroughs in innovation in the use of information technologies and the management of their businesses. In 2009, Mohawk received the prestigious Leadership Mastery Award from Managing Automation for environmental stewardship. Also in 2009, Mohawk and was named the number (#1) Green IT Organization by Computerworld. This researcher, Vice President of Information Technology at Mohawk, was named a "Premier 100 IT Leader" by Computerworld in 2010 and a "Practitioner Pro to Know" by Supply & Demand Chain Executive in 2012. In April 2012, Mohawk received the CIO-Mid-Market Technology Innovation Award in recognition of the contributions from this research study as being the most innovative among global medium-sized enterprises. In August 2012, Mohawk received the prestigious CIO 100 Award from CIO Magazine in recognition for the innovation and business impacts of the research presented in this thesis.

Table 1 presents a summary of Mohawk's information technology (IT) leadership awards and recognitions received over the past five years. The awards and recognitions for 2011 and 2012 are based on the outcomes and results from this research presented in this thesis.

Year	Publication	Award or Recognition	Category
2008	Managing Automation	Progressive Manufacturing 100	Supply Chain Leadership
2009	Managing Automation	Progressive Manufacturing 100	IT Sustainability
2009	Managing Automation	Leadership Mastery Award	IT Business Model
2009	Computerworld	Top Green IT Organization	IT Sustainability
2010	Managing Automation	Progressive Manufacturing 100	Cloud Computing
2010	Computerworld	Premier 100 IT Leader	IT Leadership
2011	Managing Automation	Progressive Manufacturing 100	Cloud-Based Integration
2012	Supply & Demand Chain	Practitioner "Pro to Know"	Supply Chain Leadership
2012	Mid-Market CIO	Technology Leadership Award	Cloud Business Model
2012	CIO Magazine	CIO 100 Award	Cloud Business Model

Table 1. Mohawk IT Leadership Awards and Recognitions

1.1.3 Industry Shifts Demand New Business and IT Strategies

Significant technological and market dynamics are rapidly changing how premium paper products are manufactured, delivered, and consumed. In the past several years there has been a steady decline in the global demand for premium paper products driven by increased competition, energy costs, environmental awareness, and most significantly the digitization of media for consumption on proliferating numbers and types of web-enabled mobile devices. Collectively, these disruptive technologies and unfavorable market forces have resulted in a significant shift in the very structure of the paper and printing industry presenting a serious challenge to the near-term profitability and long-term viability of an enterprise that has been successfully operating for eighty-years. To survive, Mohawk would need to transform its business strategy in response to these distributive market forces and structural changes in the industry. Mohawk's transformation would require a transition from a predominant product-orientation towards service-orientation in the business and technology domains. In the business domain, service-orientation takes the form of a dynamic network of business partnerships designed to offer new and value-added products and services to customers. As in the past, Mohawk would need to effectively leverage information technologies to enable the business transformation. For Mohawk, the technology transformation would require a shift from a primary focus on internal operating efficiencies and supply-chain optimization towards the design and use of service-oriented technologies to enable interoperability and collaboration with external business partners in configurations of dynamic value service networks.

1.1.4 Mohawk's Business Strategy Transformation

For many decades, Mohawk's go-to-market business strategy was to sell paper products to a network of several hundred distributors who maintained inventory and sold paper products directly to printers. As a result, Mohawk's information systems and business processes were designed and optimized to execute transactions across a traditional supply chain to distributors. In this model, there was only minimal interaction with the ultimate consumers of Mohawk paper products However, in response to declining demand for premium paper products, Mohawk needed to complement its sell-to-distribution model by establishing new channels to directly access the consumers of premium paper products. The pursuit of this business strategy would significantly expand Mohawk's traditional business-to-business (B2B) channel from several hundred distributors to many thousands of designers, printers and corporate end-users. In addition, the business strategy required the establishment of business-to-consumer (B2C) capabilities to enable web-based electronic commerce sales directly to small and medium-sized enterprises and retail consumers. In support of this new direct go-to-market business strategy, Mohawk launched a suite of eCommerce web-sites targeting digital printers (MohawkConnects.com), print designers (FeltandWireShop.com), and retail customers (MohawkPaperStore.com).

Fundamentally, Mohawk was embarking upon a business strategy to augment its traditional business-to-business model with a business-to-consumer model to access a larger base of customers with a more comprehensive offering of products and services. To accomplish this, Mohawk would need to establish relationships with a network of business partners and service providers to offer its customers with new and differentiated products and services. Mohawk established partnerships with a number of manufacturers and envelope converters to expand its paper product portfolio. Several acquisitions were conducted to expand the product and service offerings. Mohawk acquired Bravo Digital Solutions to include digital substrates (synthetic and magnetic materials) into its product offering. Mohawk acquired LabPrints, a start-up company that developed software solutions to connect professional photographers to a network of high-end digital printers. Collectively, this business strategy represented the design of a business network of partners capable of offering value-added services, a service value network, that targeted new markets with new and differentiated products and services.

A key component of Mohawk's business strategy and transformation is the recognition that its product-oriented business model needed to be augmented with services. In particular that services, defined as the application of competences (knowledge and skills) by one entity for the benefit of another (Vargo and Lusch, 2006), would help differentiate premium paper products, generate additional revenue streams, and establish Mohawk as an authoritative resource at the intersection of digital and print technologies. In response, Mohawk pursued the development of several on-line service platforms (MohawkMakeReady.com) to provide professional services to small and medium-sized digital printers, and an on-line software platform (PinholePro.com) to enable professional photographers design and generate high-end photo products (PinholePress.com). This approach represents a business strategy that fosters value co-creation between parties (Vargo and Lusch, 2008). In this context, value co-creation is an emerging business, marketing and innovation paradigm that describes how customers become active participants in the design and development of highly personalized products, services, and experiences (Etgar, 2008; Payne et al., 2008). This participation and co-creation by partners and customers is enabled “through multiple interaction channels” leveraging the Internet (or “Cloud”) as a business technology platform (Sawhney et al., 2005; Nambisan and Baron, 2009). For Mohawk, value co-creation includes activities such as helping digital printer’s production processes to become more efficient, by helping small and medium-sized printers target emerging business opportunities and new customers, and by providing professional photographers with software services to generate additional revenue from print-on-demand web-sites. All of these actions are designed to generate additional service-related revenue opportunities and increase demand for Mohawk’s paper products.

Mohawk’s business strategy transformation was formally announced at the conclusion of this research study in April 2012. In a public press release entitled ”*Mohawk Reinvents the Way it does Business, Transforms Face to the World*”, Mohawk’s Chairman and CEO stated “the new Mohawk will focus on high-margin and innovative products and services that bring customer value through strategic acquisitions and partnerships and that is built to respond to changes in technology and the business environment.” In the press release, the design and deployment of the cloud-based service-oriented architecture was specifically credited as an enabler of Mohawk’s business transformation by “providing the basis for enterprise agility in the formation of business partnerships.” Figure 1 below summarizes the extent of Mohawk’s business transformation conducted over a two year period and enabled by this research and its outcomes presented in this thesis. The company changed its name from Mohawk Fine Papers to Mohawk to emphasize the transition beyond paper manufacturing towards services.

Mohawk rebranded its corporate identity and logo to signify the increased importance placed upon "business connections" designed to deliver new products and reach new markets and customers. The logo symbolizes "the connections Mohawk is leveraging in the digital, design and photo spaces to develop new web-based offerings, as well the strategic partnerships." A network of partnerships was established to expand Mohawk's product portfolio and to provide its customers with complementary value-added services. Mohawk's customer base increased from approximately 300 paper distributors to more than 30,000 customers directly accessed through newly formed internet-enabled channels. This thesis presents how emerging service-oriented technologies and design approaches enabled the transition of Mohawk towards a service-oriented enterprise.

Figure 1. Mohawk's Business Strategy Transformation

In summary, the context of this case study is a transformation of mid-sized manufacturing firm in response to significant and disruptive changes in the marketplace. The product-orientation and supporting supply-chain model that had been the foundation of Mohawk's business strategy for eighty-years would be supplanted with a model based on partnerships, service value networks, service provisioning, and value creation. Mohawk would need the capability to dynamically configure networks of suppliers, outsourced manufacturers, third-party logistics providers, and software service providers to offer new products and services to a larger and more diverse customer base. At the core, this transformation represents a fundamental shift from a manufacturing goods-based enterprise towards a service-oriented enterprise.

1.1.5 Mohawk's Information Technology Transformation

The capability and effectiveness of which firms can enable inter-enterprise integration will increasingly determine competitive advantage (Ettie and Reza 2001; Piccolo and Ives, 2005; Vitharana et al., 2007; Zhao et al., 2008). Mohawk's business transition towards a service-oriented enterprise would require a robust and agile technical infrastructure to enable the dynamic configuration of service systems and networks. The technical infrastructure would need to effectively support the seamless integration of Mohawk's internal core capabilities represented as multi-enterprise business processes with the complementary capabilities of a network of partners. For the past decade, service-oriented management and technologies have promised a way to enable the enterprise to respond to changing business requirements by creating flexible systems, applications and processes. Service-oriented architecture as a design philosophy seeks to represent discrete business functionality as shareable, reusable, and well-defined services which can be invoked in a particular sequence and context to form business processes. Technically, service-oriented architecture promotes a loosely coupled architecture that is supportive of the design, discovery and the use (and re-use) of flexible business services, thereby facilitating sharable business capabilities across the boundaries of the enterprise.

In practice, service-oriented architecture deployments have been mainly pursued by larger enterprises seeking to integrate their complex portfolio of internal enterprise systems. These service-oriented architecture deployments were technically focused on application integration and did not explicitly pursue flexibility in the design and delivery of business processes. Moreover, most of these enterprise deployments of service-oriented architecture required the purchase and implementation of highly complex and expensive enterprise application integration (EAI) or business integration "middleware" solutions. Thus, for medium-sized enterprises, many with limited financial and technical resources, enterprise-class business integration solutions are not affordable or feasible to effectively implement, manage, and support. Hence, the primary motivation for this research is to design a novel IT artifact that enables this medium-sized enterprise to cost effectively design and deploy a wide-range of multi-enterprise business processes leveraging a service-oriented approach. Further, to enable Mohawk's transition to a service-oriented enterprise, the desired solution needed to accommodate both traditional and emerging cloud-based business integration use cases and scenarios to enable the formation a comprehensive network of partners for the purposes of value creation.

For many decades, companies like Mohawk have externally sourced traditional business-to-business and traditional supply chain business process integration to service providers that used electronic data interchange (EDI) and value-added networks (VANs). A core premise of this case study and design science research is that this proven capability and platform could be enhanced to also accommodate emerging cloud-based integration requirements. In particular, by embracing the synergistic benefits of service-oriented architecture and cloud computing, these traditional value-added networks could evolve towards a service-oriented infrastructure offered as a cloud service. In concept, this vision of a technical infrastructure would increase the range of business integration capabilities and speed of deployment by representing traditional business-to-business and emerging cloud-based functionality as services accessed on-demand and ready for composition and orchestration in inter-firm or multi-enterprise business processes. Moreover, because this technical infrastructure would leverage the favorable economics of emerging cloud computing service delivery models (e.g. elasticity, scalability, pay-for-use), the approach and solution has the potential to be more attractive, manageable, and affordable to medium-sized enterprises.

Thus, the motivation for this research was to address a gap in the current solution landscape by designing a cost-effective and scalable enterprise-class business integration solution that accommodates the full range of traditional and emerging cloud integration requirements by leveraging a services-based approach and cloud computing deployment model. The design of this novel approach to business integration was pursued in the context of the Syracuse University Professional Doctorate program and in a collaborative effort between Mohawk and Liaison Technologies, a business-to-business integration service provider. A design science research in information systems (DSRIS) methodology was employed to conduct primary and secondary design activities in the case study environment. The primary phase pursues the design, development, and evaluation of a cloud-based service-oriented infrastructure with a supporting business model that provides a range of value-add integration services. For the purposes of this study, this suite of technologies and services are generally referred to as the cloud business integration platform. Gartner refers to this emerging suite of technical capabilities as an integration Platform-as-a-Service (iPaaS) and integration services as a Cloud Services Brokerage model (Pezzini and Lheureux, 2011). It is upon this cloud-based platform that the enterprise, Mohawk in this case study, conducts secondary designs to deploy a wide range of multi-enterprise business processes to integrate its internal capabilities with those of a network of business partners.

1.2 Research Study Purpose and Significance

As described in the preceding section, this research study explores the transition of a mid-sized manufacturing enterprise towards a service-oriented enterprise. At the core, this case study examines how a predominantly product-oriented enterprise is leveraging emerging cloud technologies to transition towards a service-oriented business model in response to significant and disruptive market forces. The transformation towards service-orientation is occurring at multiple levels in the organization, in the business and technology domains. As a business strategy, service-orientation enables more direct interaction with customers and focuses on the delivery of product and service bundles as a means of differentiation, value-creation, customer retention, and revenue generation.

Mohawk's business strategy transition towards a service-oriented enterprise is enabled by the design and use of service-oriented management and technologies. Mohawk's vision is to design a cloud business technology platform that enables the flexible design, deployment, and governance of a wide range of business processes across the enterprise. To accomplish this, the study pursues an initial primary design that leverages service-oriented architecture and cloud computing to establish an integration Platform-as-a-Service (iPaaS). The guiding design philosophy in this initial phase is to abstract the enterprise user from the underlying technical complexities of the service-oriented infrastructure to enable a more direct focus on business process management. It is upon this cloud integration platform that Mohawk's enterprise users would conduct many hundreds of secondary business process designs, each focusing on value co-creation in the context of their use. In the secondary design phases, a service-oriented design paradigm is pursued to leverage the flexibility of business services to enhance business process agility. For the purposes of this study, business process agility is defined as the capability of the enterprise to dynamically adapt its business processes in response to changing market threats and opportunities. In this context, the research study pursues a design-based business problem and presents the research question as: how does a cloud-based architecture enable business process agility in a medium-sized manufacturing enterprise?

To answer the research question, the case study explores how Mohawk pursued the design of an emergent and innovative cloud services brokerage model and how it leveraged this cloud integration platform to execute hundreds of process designs to facilitate integration with business partners and cloud service providers. Mohawk provides the setting for this case study research with unprecedented insider access by this researcher to pursue design science research in information systems. The goal of design science research in information systems is to invent or create new, innovative IT artifacts for purpose of improving or solving identified organizational problems and then communicate contributions to academic and practitioner audiences (Hevner et al., 2004, Järvinen, 2007). In design science research in information systems, design is a process (set of activities) and a product (artifact) – a noun and a verb (Walls et al., 1992). The outcomes from design science research in information systems are classified as constructs, models, methods, and instantiations (March and Smith, 1995). This single case study research and design science research seeks to make contributions to the scholarly knowledge base of design by informing key constructs (terms and vocabulary) of service-orientation in the business and technology domains, though the design of a cloud services brokerage model (relationships among constructs), and the demonstration of new methods (how-to-knowledge) to conduct service-oriented business process designs, and by evaluating an instantiation (representation of an abstract concept in an actual instance) of a novel cloud-based business integration platform. The case study explores how an emerging cloud-based integration platform enables a new class of secondary designs by the enterprise that leverages a services-based approach, enables collaborative design in the unique context of partners, and embraces the indeterminacy of design outcomes.

In summary, Mohawk offers a unique case study environment to explore the transformation to service-orientation in the business and technology domains. In response to disruptive market dynamics, Mohawk must transition towards a service-oriented enterprise to ensure its near-term profitability and long-term viability. As in the past, Mohawk will leverage its thought leadership in the use of information and communications technologies to enable the business transformation. The transition from a predominant product-orientation towards a service-orientation will pervade all levels of the enterprise to include strategy, architecture, computing, and business process design. The primary motivation and contribution of the case study and design science research is to inform the design (artifacts and processes) at the convergence of service-oriented architecture and cloud computing. Leveraging a design science research in information systems methodology, an initial design phase is pursued to establish a novel cloud integration platform to enable ongoing secondary designs using a service-oriented approach to effectively integrate external partners into enterprise systems, processes, services, and data. This study seeks to address gaps in the scholarly literature and to provide actionable recommendations to the IT practitioner community. The results from the study may be most applicable to medium-sized manufacturing enterprises seeking to augment their products with different types of service offerings. In the technology domain, the research seeks to provide practical insight into the adoption of cloud computing through a unified inter-enterprise architecture that supports seamless integration between internal and external business services. In the business domain, the research study seeks to provide insight into the design and configuration of value networks and service systems as a means of value-creation for the enterprise and its customers.

CHAPTER 2
LITERATURE REVIEW
TOWARDS A SERVICE-ORIENTED ENTERPRISE

2.0 Chapter Overview

The primary objective of this literature review is to provide a context for the importance and meaning of the thesis topic and supporting research question. A review of prior scholarly research, books, and other sources was conducted to introduce relevant terminology, to provide supporting evidence for the practical problem the research is addressing, to provide an overview of the current context in which this research is situated, and to describe related research in the field and how this study seeks to contribute to the existing knowledge base.

The literature review chapter begins with an overview of several key terms and definitions that are foundational to understanding the thesis topic and research question. The terms "service", "service-orientation", and "business process agility" are defined in the context of available scholarly research. Given the emergent and complex nature of the research topic, other relevant terms and definitions are presented throughout this chapter and summarized in the Appendix of this document. The chapter proceeds with an introduction of the notion of a service-oriented enterprise as an aligned business and technology strategy to integrate enterprise business processes with a network of business partners for the purposes of value creation. This review of the scholarly research positions the transition towards a service-oriented enterprise in the context of the digitally connected service economy, and with it increased importance placed upon business partnerships to deliver customer value and the unique role of medium-sized manufacturing enterprises in a service value network. The literature review examines the architecture of a service-oriented enterprise, leading to a proposition that the convergence of service-oriented architecture and cloud computing can enhance the level of business process agility in the study environment. Specifically, that the transition towards a service-oriented enterprise is enabled by leveraging a cloud integration platform and cloud services brokerage model to dynamically integrate business processes into service systems and value networks. The chapter concludes with a presentation of the research agenda, an overview of design science research in information systems (DSRIS), and a summary of the expected research contributions from the study.

2.1 Foundational Terms and Definitions

In the following two sections several foundational terms and definitions are provided in the context of the scholarly literature. This research explores a manufacturing firm's transition to a service-oriented enterprise through the effective design of multi-enterprise business processes enabled by emerging service-oriented technologies. Thus, a clear understanding of the notion of "service-orientation" is fundamental to this research from both a business and technology perspective. Similarly, a clear understanding of the term "enterprise agility" is essential as it is often cited as the desired benefit and outcome of service-orientation in the business and technology domains. In the most general terms, enterprise agility can be defined as the capability of the enterprise to effectively respond to environmental threats and opportunities through business process design and deployment (Sambamurthy et al., 2003). This research agenda is based on the principle that business strategy is enabled by business processes, and therefore enterprise agility is a function of business process agility. The notion of business process agility is defined and operationalized in the context of the literature in the following sections.

2.1.1 Service and Service-Orientation Defined

An understanding and clear definition of the terms *service* and *service-orientation* is central to this research study. The two terms are homonyms with multiple meanings and are not necessarily homogenous concepts. In the scholarly literature there are different meanings, perspectives and emphasis of the term "service" in the disciplines of economics, marketing, and computer science. In economics, service is most often used as a category to classify and measure different types of economic activities, employment, businesses, and organizations versus economic activities that produce or manufacture a physical product (Spohrer and Kwan, 2008). In marketing literature, service most often refers to the value of actions, experiences or assurances rather than the value of physical (tangible) things (Spohrer and Kwan, 2008). In this context, the term service is defined as the application of competence (knowledge, expertise, resources, and relationships) for the benefit of another entity (Vargo and Lusch, 2008). In computer science literature there are various perspectives of service (Atkinson et al., 2005). The predominant perspective in computer science literature views services (plural) as discrete business functionality implemented in software (Papazoglou et al., 2006). In this view, a service (or software service) is the unit of analysis to establish a unified language to align the structure of the enterprise with information systems (Marks and Bell, 2006). In the past several years, the term service has become known as on-demand computing (Demirkan et al., 2007; Marks and Lozano, 2010) where computational resources (infrastructure, platforms, and applications) are discovered, accessed, and delivered "as-a-service" using standard protocols (Spohrer and Kwan, 2008).

Similarly, the term "service-orientation" has duality of meaning. Service-orientation is a broad concept for describing and designing phenomena as different as products and services in a service system or value network or the interface definition and functional description of software components and business processes (Aier et al., 2011). Ultimately, the objective of service-orientation is to create value for the enterprise and customers using a set of policies, practices, and procedures intended to foster the creation and delivery of service excellence (Lytle and Timmerman, 2006). In the literature, service-orientation is often described as a design paradigm to develop information systems using services (Erl, 2004; Papazoglou et al., 2006). This view promotes the design of information systems, applications, and business processes using services that are modular, sharable, loosely coupled, technology neutral, and location transparent, thereby making them more flexible, agile and adaptable to change (Marks and Bell, 2006; Papazoglou et al., 2006; Luthria and Rabhi, 2009). Services have also been described as the basic building blocks to compose and orchestrate flexible business processes (Arsanjani et al., 2008; Aier et al., 2011). In recent years with the emergence of cloud computing deployment models, the notion of service-orientation has taken on a new and broader meaning beyond the flexible design of information systems and applications. As we shift from a product-based economy towards a digitally networked service-based economy, computing resources are increasingly being offered to the enterprise by cloud providers "as-a-service" (Lui et al., 2011). Three primary cloud computing service models have emerged to provide the enterprise with cloud-oriented infrastructure, platform, and software capabilities (Mell and Grance, 2011). These cloud computing deployment models embrace the notion of being service-oriented when enterprise users are able to interact and configure these resources in the context of their unique requirements (Tsai et al., 2010).

All of the aforementioned perspectives of service-orientation in the scholarly literature are represented and applicable in this research study. The initial or primary design phase of this study will pursue a cloud integration platform that will deliver infrastructure, platform, and software capabilities "as-a-service". In complementary secondary design phases, enterprise users interact with the capabilities inherent in the cloud integration platform to discover, compose and orchestrate business services to deploy a flexible multi-enterprise business processes. In secondary designs, enterprise users are empowered to leverage sharable and modular business services to establish interoperability between enterprise and partner systems, applications, and data. In this context, the study's research question examines how the convergence of service-orientation and computing delivered as-a-service can enable the enterprise to more effectively design, configure, deploy and manage diverse range of multi-enterprise processes in response to changing business threats and opportunities.

In this study, service-orientation has meaning and importance as a business strategy based on partnerships to access new customers and to offer them additional products and services beyond those offered by the enterprise alone. In the service-oriented enterprise, inter-firm or multi-enterprise business processes are the means to integrate the internal capabilities of the enterprise with those of a network of partners to offer customers with a differentiated value proposition. These multi-enterprise business processes enable the exchange of value between the enterprise and its network of business partners, which ultimately offer value propositions to its customers. In the literature, collections (e.g. a network) of multi-enterprise business processes are described as service systems and service value networks (Luthria and Rabhi, 2009; Chen and Vargo, 2010), which are partnerships purposely designed to offer value propositions to customers. A service value network has been described as a loosely-coupled formation of companies that provide complementary services while enabling the service-oriented enterprise to concentrate on their core competencies (Blau, 2008).

A general theme of this research agenda is the recognition of the emergence of a global and digitally connected service-based economy and the transition of a predominately product-based enterprise towards service-orientation. Thus, to achieve a clearer understanding of service-orientation, it is useful to examine the characteristics of service and the relationship with products. The scholarly literature indicates that researchers have differing views on how products and services should be distinguished, how services should be defined, and how service innovation can be designed into enterprise systems and processes. In the marketing literature, researchers have focused on establishing clear differences between products and services (Fisk et al., 1993; Lusch et al., 2008; Spohrer, 2008). Traditionally, services have been differentiated from products on the basis of four primary characteristics: intangibility, heterogeneity, inseparability, and perishability (Zeithaml et al., 1985); which have provided the underpinning for the position that services marketing is different than goods marketing (Fisk et al., 1993).

More recently, marketing scholars have begun to challenge the four foundational attributes of services citing numerous exceptions when comparing products and services (Vargo and Lusch, 2004; Lovelock and Gummensson, 2004). Instead, some researchers argue that an understanding of service and service innovation requires new ways of thinking (worldview or logics) – where the basic unit of service is the service system (Spohrer, 2008). They offer two perspectives of service(s). One perspective referred to as a goods-dominant logic (G-D logic) is centered on the good or product that includes both tangible (goods) and intangible (services) units of production (Spohrer, 2008; Vargo and Lusch, 2004). Goods-dominant logic implies that production and distribution practices should be modified to accommodate the differences between tangible goods and services.

The second perspective, referred to as a service-dominant logic (S-D Logic), defines service as the application of competencies for the benefit of another party (Vargo and Lusch, 2006). Service-dominant logic identifies service as the main focus of exchange without reference to goods. The service-dominant logic emphasizes "value-in-use" and "value-in-context" rather than the more traditional "value-in-exchange" perspective in goods-dominant logic (Chen and Vargo, 2010). In service-dominant logic the notion of 'producing' a product shifts to the notion of "resourcing" through a collaborative process of value-creation among business partners (Vargo and Lusch, 2008). The S-D logic views the customer as a co-creator of value and results in relationships that converge on value creation in service systems (Vargo and Lusch, 2006). Chen and Vargo (2010) argue the adoption of service-dominant logic in Service Science and Design Science will advance the transition towards service-orientation. Khoshafian (2007) argues that service-dominant logic provides the foundation on which to create a service-oriented enterprise.

Further review of the literature suggests there are contrarian perspectives in the research to distinguish services from products. For example, Araujo and Spring (2006) argue that the marketing literature focuses on the intrinsic characteristics of services with a bias towards implications for the management of service-based firms. They argue that rather than focus on the intrinsic distinctions between products and services, researchers should focus on products and services as complementary. Goldhar and Berg (2009) argue the separation of the design and management of services from traditional manufacturing is misguided. As services are continually adopting the characteristics of manufacturing as they expand and gain increased profitability and economies of scale. Hsu (2009) supports this position and argues digitally connected services represent a transformation pathway for manufacturing.

This stream of research suggests that the study of service and services has evolved towards "bundled solutions" comprising of products and services, where "everything is a service" (Levitt, 1972) and where products become "vehicles for service delivery" (Araujo and Spring, 2006). In the service economy, customers are increasingly demanding integrated solutions that accommodate individual needs instead of buying standardized physical goods (Vargo and Lusch 2004, 2008). Manufacturing firms are addressing this demand by integrating services with their products (Johnansson et al., 2003; Hamilton and Koukova, 2008). This perspective has been described in the literature as "servitization" (Vandermerwe and Rada, 1988), "hybrid value bundles" (Cavalieri and Pezzotta, 2012), and "product-service systems" (Augsburg, 2011), each characterizing a process of value-creation through bundling services to physical products (Oliva and Kallenberg, 2003; Schroedl and Turowski, 2011).

This perspective underscores the close and symbiotic relationship between products and services and blurring the sometimes arbitrary distinction between the two. Thus, for the purposes of this study, service represents business functionality in business processes that are extended in the form of digitally connected services for the purposes of offering value propositions within a service value network of business partners. This perspective of the terms service and service-orientation informs the notion of a service-oriented enterprise. In a service-oriented enterprise, business services provide the foundation for the design of business processes that enable interoperability of the firm's capabilities with a network of business partners designed to offer customers with innovative product and service bundles.

2.1.2 Business Process Agility Defined

As contemporary firms are confronted with globalization, increasing competition, and time-to-market pressures, flexibility and agility are considered to be an imperative for business success (Amit and Schoemaker, 1993; Goldman et al., 1995). Although enterprise flexibility and agility are suggested as important organizational capabilities, a review of the scholarly literature suggests these two concepts are not well-defined, lack empirical measurement, and their contribution to enterprise performance requires validation (Vitharana et al., 2007;

Sengupta and Masini, 2008). Adoption of service-orientation as a business and technology strategy has been promoted as an approach to help make the enterprise and its architecture, applications, and business processes more flexible and agile (Artus, 2007; Crawford et al., 2005; Zhao et al., 2007). Therefore, given the emphasis on the terms flexibility and agility in the context of a transition towards a service-oriented enterprise, it is important to establish a clear understanding of meaning, similarities and differences of these terms.

There is growing interest in the concept of enterprise agility, particularly in practitioner-based sources, claiming fundamental differences with the established concept of enterprise flexibility (Baker, 1996). Prior literature has examined the ability of the enterprise to adapt at the business process level, often using the terms flexibility and agility synonymously (Raschke et al., 2005; Schelp and Aier, 2009). However, there appears to be some agreement in the literature that flexibility is a component of agility (Yusef et al., 2004). Flexibility is a response to expected changes in the environment, whereas agility is the capability to adapt to unexpected changes (Vokurka and Fliedner, 1998; Sharifi and Zhang, 1999; Yusef et al., 1999; Zhang and Sharifi, 2000). According to Schelp and Aier (2009) flexibility is 'built-in' by considering configurability early in the design process. They argue that configurability fosters flexibility, but provides minimal contribution to unexpected changes, because only expected changes are typically considered at the design stage. This view is consistent with Wadhwa and Roag (2003) who define flexibility as the ability to accommodate change by exploiting what is controllable. There is broad agreement in the literature that flexibility is achieved by exercising the range of available options in an effective and efficient manner with lesser transition penalties such as time, cost and quality (Upton, 1995; Wadhwa and Roa, 2000). This view is consistent with Chen and Vargo (2010) who attribute flexibility with a goods-dominant logic where requirements are known. Chen and Vargo (2010) argue the adoption of a service-dominant approach to design thinking and design science research will promote enterprise agility by embracing the indeterminacy of the customers wants and needs as they are emergent and not yet created.

The notion of the agile enterprise originated in the early 1990's based on the realization that the pace of change in the business environment was accelerating and outpacing the abilities for many enterprises to respond (Dove, 1999). Since its inception, the concept of enterprise agility has resulted in multiple perspectives from researchers and practitioners (Amram and Kulatilaka, 1999). In their well-cited research, Goldman et al. (1995) define agility as being "dynamic, context specific, aggressively change-embracing, and growth-oriented." Vokurka and Fliedner (1998) describe agility as the capability to produce and market successfully a broad range of low cost and high quality products with short lead-times in varying lot sizes, thereby providing value to customers through customization. Meredith and Francis (2000) define agility as the organizational capability and capacity to achieve competitive advantage by intelligently, rapidly and proactively seizing opportunities and reacting to market threats. Sharifi and Zhang (2001) observe that agility is an effective and efficient response to change (anticipated or unexpected) that exploits an explicit opportunity. Yusef et al. (2004) define agility as the integration of reconfigurable resources and best practices to provide customer-driven products and services in a changing market environment. Raschke et al. (2005) argue that to be agile, the enterprise must have the capability to redesign and reconfigure discrete business process components by combining individual tasks and capabilities in response to an external event or opportunity. In summary, the available scholarly research suggests that flexibility primarily focuses on managing predictable change with a predetermined response, whereas agility focuses on managing the unpredictable change in an innovative manner.

The strategic management literature has recognized that enterprise agility is a construct comprised of dimensions customer, partnering, and operational agility (Ferrier et al., 1999; Sambamurthy et al., 2003). Customer agility is the leveraging of customer relationships for innovative ideas potentially leading to new product and service bundles (Tsourveloudis and Valavanis, 2002). Operational agility is the capability of the firm's business processes to accomplish speed, accuracy, and cost effectiveness in the exploration of opportunities for innovation and competitive action (Sambamurthy et al., 2003). Partnering agility is the capability of the enterprise to leverage the assets, knowledge, and competencies of suppliers, distributors, manufacturers, and logistics providers through collaboration and partnership (Venkatraman and Henderson, 1998). Choudhury and Xia (1999) define partnering agility as the capability of the enterprise to design a service value network of strategic, extended, and virtual partnerships for the purposes of value creation.

This stream of research suggests that enterprise agility is an organizational response to both current (known) and future (unknown) threats and opportunities in the environment which leverages the firm's capabilities with those of a network of partners to offer innovative value propositions to customers. Moreover, there is evidence in the literature that suggests inter-organizational processes, also referred to as multi-enterprise processes, provide the basis for enterprise agility (Yusef et al., 2004; Raschke et al., 2005; Zhao et al., 2007; Tallon, 2008). For the purposes of this research study, multi-enterprise business processes are defined as a dynamically coordinated set of collaboration and transactional activities that occur between the firm and network of partners to deliver value-propositions to customers (Johnston and Lawrence, 1988; Davenport, 2005). As inter-firm or multi-enterprise business processes are the fundamental components of how the enterprise interoperates and collaborates with its partners, the ability to respond and adapt in a dynamic environment is highly dependent on the agility of its business processes (Raschke and Smith, 2005; Seethamraju, 2006; Fingar, 2009). In a networked service-based economy with increasing numbers digital connections with business partners and cloud service providers, business process agility is an enabler in the transition towards a service-oriented enterprise (Vitharana et al., 2007; Poulin, 2009).

Raschke et al. (2005) define business process agility as the capability of the enterprise to dynamically modify and reconfigure their business processes from a broad range of business process capabilities to accommodate both the required and potential needs of the enterprise. According to Sambamurthy (2003) a firm may modify their business processes in response to a number of environmental factors to include changes in customer demand, the need to customize a product to a specific customer or market segment, in response to new products or services in the marketplace, in response to changing prices or product mix, to enter or exit certain market segments, to adopt emerging information technologies, and to redesign their demand and supply chains.

Based on previous research (Prater et al., 2001; Johnson et al., 2003; Sambamurthy, 2003) business process agility may be measured by the capabilities and speed with by which the enterprise undertakes business actions. Prater et al. (2001) argues that an agile enterprise must design its business processes such that they can respond to change, where business process agility can be measured as the speed and range of response. This view is consistent with Sengupta and Masini (2008) who define business process agility as a two dimensional factor operationalized as range agility and time agility (Masini and Sengupta, 2005). Range agility represents the firm's ability to broaden (or reduce) specific aspects of their business process capabilities. Range-agility provides the enterprise with the ability to configure their business processes to add or subtract products and services and to establish and sustain a network of collaborative business partnerships (Sengupta and Masini, 2008). Time agility is the speed, measured as the least possible time and cost, to exercise a range of organizational capabilities through business process design, reconfiguration and execution (Bharadwaj, 2000; Sengupta and Masini, 2008; Tallon, 2008). Several researchers argue that the highest level of business process agility may be realized from the design and execution of multi-enterprise business processes that are real-time, contextual, and event-driven (Alexopoulou et al., 2010) and enabled by service-orientation and cloud computing (von Ammon et. al, 2010; Torkashvan and Haghighi, 2012).

In summary, enterprise agility is the ability of the firm to effectively respond to planned and unexpected changes in the environment in collaboration with a network of partners with the goal of delivering innovative and products and services to customers. Enterprise agility is enabled by business process agility which can be operationalized as the ability of the firm to dynamically configure multi-enterprise business processes to deliver value-added products and services to its customers, measured in the dimensions of range and time.

2.2. Towards a Service-Oriented Enterprise

In this section, the notion of a service-oriented enterprise is presented in the context of the available scholarly literature. The presentation starts at the macro-economic level situated in the digital service economy and the growing prominence of business strategies based on a network of partnerships. A review of the scholarly literature is presented on the particular role of medium-sized manufacturing enterprises in the networked service economy. The section concludes with a survey of the literature on the notion of an emerging architecture of firm, the service-oriented enterprise, enabled by the paradigm of services-computing.

2.2.1 Digitally Connected Service Economy

The global economy is going through a transformation from a goods focus to a service focus, often characterized as shift from a manufacturing economy to a service economy (Chen and Vargo, 2010). Service-related activities now represent the majority of economic activity in the United States (Chen, 2008) and 80% of private sector employment (Karmakar, 2004). Service activities encompass a broad and diverse range of activities including health care, legal, utilities, education, financial, government, and information technology. The drivers for the prominence of services in the economy include global competition, pressures to innovate, and changing customer demands and expectations (Basole and Rouse, 2008). In part, the growth in the service economy is fueled by manufacturing enterprises as they seek to complement their products with services as a strategy to differentiate their products, to increase revenues, and to expand access to new customers (Rai and Sambamurthy, 2006; Gao et al., 2011). Servitization, defined as the tendency of a manufacturing firm to augment their product with service offerings, has become one of the most prevalent trends in the manufacturing and high technology sectors in last several years (Fang et al., 2009). Prior research indicates that between 30% and 70% of added value and earning potential in a typical manufacturing firm can be attributed to service activities (Machuca et al., 2007). As manufacturing enterprises augment their products with service offerings, the delineation between the manufacturing and service sectors is increasingly blurred (Vargo and Lusch, 2004) as is the differentiation between products and services (Goldhar and Berg, 2009).

2.2.2 Overview of Service Value Networks

The digitally connected service-based economy is transforming how enterprises conduct business by enabling new types of business models based on the dynamic configuration of service systems and value networks (Bitsaki, et al., 2008). As manufacturing enterprises pursue servitization they are making structural changes to transition from a primary focus on products towards service-orientation (Spohrer, 2008; Vargo and Lusch, 2004; Korhonen et al., 2010). This represents a fundamental shift in the logic that manufacturing enterprises employ to shape their business strategy, to create profitable customer relationships, and to offer value propositions to customers (Agarwal et al., 2004). As a consequence, strategic value no longer resides only within the internal value-chain of the firm. The traditional view of the enterprise value-chain (Porter, 1998) assumed a linear flow of resources from raw material providers to manufactures to suppliers and then to customers. Researchers argue that Porter's value-chain model does not adequately describe the multi-directional nature of the business-to-business, business-to-consumer, and consumer-to-consumer relationships observed in the digital service economy (Normann and Ramirez, 1993; Bovet and Martha, 2000). As a result, the traditional value-chain prominent in prior decades has evolved into service value networks (Holweg and Pil, 2006; Blau et al., 2009). Moreover, the notion of the supply-chain with a focus on supply and movement of tangible materials for manufacturing has shifted to a broader focus on partnerships, relationships, and service networks (Min et al., 2007). In this context, the supply chain itself has become an embedded component of a service value network (Bovel and Martha 2000; Lusch et al., 2009).

In today's digitally networked service economy, product and service bundles are designed, created, and delivered to customers via a complex set of business processes, exchanges, and relationships (Fitzsimmons and Fitzsimmons, 2004). The focus has shifted from business transactions to business relationships for the purposes of value-creation. Thus, business processes are becoming more inter-organizational where one entity applies competence and the other integrates the applied competences with other resources for benefit and value co-creation (Spohrer, 2008). These interacting entities are referred to as service systems – the basic unit of analysis of service (Maglio and Spohrer, 2007). Service systems are defined as a dynamic value co-creation configuration of resources, including people, organizations, shared information, and technology, connected internally and externally to other service systems by value propositions (Maglio and Spohrer, 2007). Configurations of different types of service systems are combined to form service value networks (Tien and Berg, 2003; Lucsh et al., 2010). Service value networks leverage the complementary resources of service providers to create customer value propositions (Blau et al., 2009; Holweg and Pil, 2006; Lasnsiti and Levien, 2004; Kwan and Yuan, 2011). In service networks, customer value is established through the integration of complementary partners and service providers, each of whom contributes to incremental added value to the overall product and service offering (Bovet and Martha, 2000; Basole and Rouse, 2008). In the digitally networked service economy, competition has evolved from company to company, and supply chain to supply chain, towards service value networks that leverage the dynamic configuration of partners for the purpose of value-creation (Zhao et al., 2008; Fingar, 2009).

2.2.3 Manufacturing SMEs and Service Value Networks

The emergence of service value networks presents both an opportunity and challenge for small and medium-sized enterprises (SMEs), which represent the preponderance (99%) of enterprises in the United States (SBA, 2011). In this research study, a small and medium-sized enterprise in the manufacturing sector is defined as having less than $500 million in total annual sales or fewer than 1000 employees (SBA, 2011). Small and medium-sized firms have become central to value-creation in service networks by leveraging their unique value propositions, flexibility, and lower cost structures (Fingar, 2009; Lin et al., 2009). This has occurred in part because large and multinational enterprises (MNEs) are “unbundling” and “re-assembling” in partnerships with smaller more agile firms to establish opportunities for cost control and value creation (Tapscott, 2000; Iansiti and Levien 2004; Cherbakov et al., 2005). For medium-sized manufacturing enterprises the globalization and fragmentation of production continuously presents new niches and opportunities to deliver innovative and complementary products and services (Dembinski, 2007; Hsieh et al., 2010). As such, the survival of medium-sized enterprises increasingly depends on their flexibility in response to changing environmental demands (Storey, 1994; McKiernan and Morris, 1994; Gupta and Cawthorn, 1996) and their capabilities to effectively interoperate in increasingly complex service value networks (Lusch et al., 2009).

Manufacturing SMEs face unique challenges as they can operate as both a service provider and service consumer in service value networks. Their role and relationship in service networks can be bilateral or multilateral, horizontal or vertical (Lin et al., 2009; Hsieh et al., 2010). In a service provider role, manufacturing SMEs must be agile in response to both the changing market conditions and the demands imposed by the larger enterprises they serve. At the same time, manufacturing SME's are increasingly consuming services from business partners to complement their products with service offerings and to achieve higher levels of competitiveness (Goldhar and Berg, 2009). This type of adaptation to market changes also requires flexible organizational structures and technical capabilities to effectively establish relationships as a supplier, business partner and as a consumer of services. Moreover, the capability of manufacturing SME's to effectively participate in service value networks is an effective strategy to overcome their resource and financial disadvantages (Merrifield, 2007; Hsieh et al., 2010) relative to larger enterprises. Prior research suggests that collaboration with business partners can help medium-sized firms to discover and share complementary resources, leverage economies of scale to reduce operational costs, and to deliver innovative products and services to customers (Navickas and Malakauskaite, 2009; Lin et al., 2009). However, these networking strategies are unlikely to emerge because SMEs are locked into their traditional competencies and they lack the financial and strategic resources to develop interactive strategies covering the entire value system (Vanhaverbeke, 2001).

To be competitive in the digitally networked service economy, manufacturing SME's will require capabilities and competencies to dynamically structure their business processes to enable collaboration with a network of business partners (Rosenfeld, 1996; Sher and Lee, 2004; Ozgur et al., 2009). To accomplish this, a robust and integrated IT infrastructure (Lee et al., 2010) is required to deliver the necessary levels of business process agility in a manner that accommodates the limited financial and technical resources typical of many medium-sized enterprises (Levy et al., 2003; Chan and Chung, 2002; Bruque and Moyano, 2007). For many decades, product-based and manufacturing SMEs have utilized service providers and value-added networks to facilitate business-to-business (B2B) interoperability between suppliers and customers using electronic data interchange (EDI) standards. However, electronic data interchange standards and approaches are known to be inflexible to change (Weitzel et al., 2000; Liu and Kumar, 2003) and were not designed to address emerging cloud integration requirements (Bolloju and Murugesan, 2012). Moreover, enterprise application integration solutions are not affordable or feasible to effectively implement, manage, and support in a typical small and medium-sized enterprise (Markus, 2000; Ross, 2003; Sharif et al., 2005).

Cloud computing is evolving as a new pathway to enterprise flexibility and agility by offering on-demand cloud-enabled infrastructures, software, applications, and business processes (Marks and Lozano, 2010). Cloud computing models are particularly attractive to medium-sized enterprises as minimal upfront capital expenditure is required (Sharif, 2010; Chien and

Chien, 2011; Sultan, 2011). However, cloud computing adoption also introduces its own set of barriers and challenges as small and medium-sized firms must be able to effectively integrate and manage externally sourced services from different types of providers and incorporate these services into their existing IT architecture (Feuerlicht and Govardhan, 2009; Huang et al., 2012). There is recognition that a service-oriented architecture in terms of the appropriate managerial policies, practices and frameworks is required to promote interoperability with cloud-based business applications, services and processes (Erl, 2004; Marks and Bell, 2006; Ravichandran et al., 2007; Linthicum, 2009). However, existing cloud computing platforms have not yet formally adopted the service-oriented architecture that would make them more flexible, extensible, scalable, and reusable (Zhang and Zhou, 2009; Dillon and Chang, 2010). Moreover, there is limited academic research on cloud computing integration (Chen, 2012) and an absence of a comprehensive enterprise architecture to guide the effective integration of cloud-based and on-premise systems, applications, and processes (Machado et al., 2009; Zimmermann et al., 2012). The most significant challenge in cloud computing integration is the absence of a single architectural method, which can meet the requirements of an enterprise cloud approach (Rimal et al., 2011). To address this gap, The Open Group recently issued a standards framework and guidance to integrate the fundamental elements of service-oriented architecture and cloud computing into a holistic solution for enterprise architecture (The Open Group, 2011).

A review of the scholarly literature and practitioner sources suggest that service-oriented architecture deployments are conducted by larger enterprises primarily to rationalize their portfolio of enterprise systems. No scholarly literature is found on the deployment of service-oriented architecture in small and medium-sized enterprises, presumably because of their relatively simple IT environments or as a result of the high cost and complexity of business application integration solutions. In recent years, the emergence of web services has presented new opportunities to achieve universal interoperability for inter-enterprise integration (Zhao et al., 2007; Demirkan et al., 2008) as a cost-effective alternative for small-medium-sized enterprises (Ciganek et al., 2006; Gupta et al., 2012). Web-services are an enabling technology and increasingly important integration approach, however, it is one of the many types of deployment patterns in a service-oriented architecture (Marks and Bell, 2006; Papazoglou et al., 2006) and does not by itself deliver a comprehensive integration solution.

It has been suggested that the basic premise on which service-oriented architecture is built needs to be re-evaluated to accommodate the challenges of cloud computing environments that involve externally sourced software and services (Feuerlicht and Govardhan, 2009). This perspective of service-oriented architecture is described as an "outside-in" adoption pattern that leverages cloud computing to integrate internal and externally sourced applications, processes, and services (Castro-Leon et al., 2009). Moreover, an outside-in SOA adoption pattern is particularly well-suited to small and medium-sized firms seeking to integrate external partners and leverage cloud-based services (Jammes and Smit, 2005; Chang et al., 2006; Castro-Leon et al., 2009; Feuerlicht and Govardhan, 2009; Thieme, 2011). The convergence of service-oriented architecture and cloud computing offers the potential for enhanced enterprise agility through the rapid provisioning of new business capabilities, but it relies upon service-oriented architecture to effectively integrate internal and external applications and processes (Fingar, 2009; Linthicum, 2009; Marks and Lozano, 2010).

2.2.4 Overview of the Service-Oriented Enterprise

To succeed in the networked service economy, enterprises must become more innovative, flexible, and faster in the presence of uncertainly, complexity, and environmental change, referred to as enterprise agility (Zhao et al., 2007). To achieve higher levels of enterprise agility, goods-based manufacturing firms are pursuing service-orientation in the business and technology domains (Vargo and Lusch, 2004; Spohrer, 2008; Vitharana et al., 2007). As the perspective has moved from products to services, enterprises have componentized their structures to conduct business in emerging collaborative networks (Korhonen et al., 2010). Enterprises have begun to focus on their core competencies and the formation of business partnerships with other enterprises that offer complementary or best-of-breed capabilities (Cherbakov et al., 2005; Korhonen et al., 2010). As such, the enterprise becomes a federation of capabilities by integrating internal business processes with those of partners in a service value network with the objective to deliver value-added services to customers (Arsanjani et al., 2008). A service value network is a loosely-coupled formation of companies that provide modularized services while enabling the enterprise to concentrate on its core competencies (Blau, 2008). This type of business strategy and structure of the enterprise represents the emergence of the service-oriented enterprise (Vitharana et al., 2007; Poulin, 2009; Alter, 2012).

There are varying definitions of the service-oriented enterprise in the scholarly literature. Brown and Carpenter (2004) define the service-oriented enterprise as an enterprise that implements and exposes its business processes through a service-oriented architecture and that provides frameworks for managing its business processes across an SOA landscape. Graves (2009) describes the service-oriented enterprise where "everything is seen in terms of services and their interactions providing consistency and simplicity everywhere, and creating new space for agility and innovation in the enterprise." Poulin (2009) defines the service-oriented enterprise as a structure of the enterprise that enables interoperability between internal processes and the processes of partners. Cherbakov et al. (2005) describe the service-oriented enterprise as having characteristics of creating business value through services provided by participants with business process flows in an ecosystem supporting dynamic and real-time business process orchestration. Alter (2012) defines a service-oriented enterprise as one consisting of multiple service systems most of which "genuinely" provide service for their internal and external customers. Mircea and Andreesc (2012) define the service-oriented enterprise as one that integrates the emerging technologies with service-oriented business processes within an approach in which each participant in the network is a provider and consumer of services.

The transition to a service-oriented enterprise represents a fundamental transformation of what the enterprise is about (business strategy) and how it functions (business operations) (Vitharana et al., 2007). The service-oriented enterprises leverages business and technology resources to deliver business functionality as well-defined services (Cherbakov et al., 2005) which provide the foundation for the flexible orchestration of business processes across the enterprise (Luthria and Rabhi, 2009). By leveraging the paradigm of service-orientation, business processes become standardized and adaptable (Raschke et al., 2005) enabling the integration of the capabilities of business partners (Legner and Heutschi, 2007) and the dynamic configuration of partners in the value network (Cherbakov et al., 2005; Holweg and Pil, 2006; Min et al., 2007; Bitsaki, et al., 2008; Lusch et al., 2009). For the purposes of this study, a service-oriented enterprise is defined as an organization whose business processes and IT infrastructure are integrated and aligned across the enterprise to facilitate business integration with a service system and network consisting of suppliers, service providers, and business partners (Brown and Carpenter, 2004; Janssen, 2007; Zhao et al., 2007; Biemborn et al., 2008) with the objective of delivering value-added products and services to customers (Demirkan et al., 2008; Fingar, 2009).

2.2.5 Overview of Services-Computing Paradigm

The realization of a service-oriented enterprise is enabled through the effective adoption of the paradigm of services-computing (Vitharana et al., 2007; Zhao et al., 2007; Joachim et al., 2009). Services-computing is an enterprise computing paradigm following an evolutionary path from monolithic, client-server, object-oriented, to service-oriented (Zhao et al., 2008). Services-computing seeks to align business services and technical services (Zhang, 2005) to establish the technological and managerial foundation to enhance enterprise agility (Zhao et al., 2007). Services-computing seeks to address the “integration challenges” occurring in many business processes, alliances, mergers, and acquisitions (Bierberstein et al., 2006) and promises to deliver on the long desired “flexibilization of the borders of the enterprise” by enabling the integration of business processes regardless of being located inside or outside the enterprise (Krafzig et al., 2005). Services-computing embraces the entire lifecycle of business processes as services to extend business functionality across the boundaries of the enterprise to integrate the needs of the customer with partners (Hagel, 2002; Smith et al. 2002; Chen, 2005; Venkatachalam, 2006; Zhao et al., 2008).

The paradigm of services-computing encompasses numerous concepts and technologies to include business process management (BPM), service-oriented architecture (SOA), service-oriented computing (SOC), service-oriented infrastructure (SOI) (Zhang, 2008; Zhao et al., 2008), and more recently cloud computing (Marks and Lozano, 2010). As the objective of services-computing is to effectively design and deploy multi-enterprise business processes, it represents a shift to towards a holistic perspective of inter-enterprise business process management (Hammer, 2001; Davenport, 2005; Bitsaki, et al., 2008) and with it a new way of managing the enterprise (Chesbrough and Spohrer, 2006; Carroll et al., 2010).

Services-computing leverages a service-oriented architecture as the IT infrastructure that enables the enterprise to become more flexible and agile through a focus on services and processes (OASIS, 2006; Zhao et al., 2008). Service-oriented architecture is an application architecture within which all functions are independent and sharable services with well-defined interfaces, which can be orchestrated in a defined sequence to form business processes (Varadan et al., 2008). In this study, a business process is defined as a collection of services, invoked in a particular sequence with a particular set of rules, to produce value for a customer (Davenport, 1992). Service-oriented architecture promotes a loosely coupled IT architecture supportive of discovery, selection and use of flexible business services (Erl, 2004; Marks and Bell, 2006), thus facilitating sharable business capabilities across and beyond the boundaries of the enterprise (Legner and Heutschi, 2007; Linthicum, 2009). In more technical terms, service-oriented computing is a software development approach that leverages services as the basic element for developing distributed applications (Huhns and Singh, 2005). Service-oriented computing is a design approach based on the premise that business logic can be organized in ways that make it independent of the context in which it's being used (Papazoglou et al., 2006).

To be effective in the adoption of a service-oriented approach to inter-enterprise business process management, a robust, flexible, and scalable technical infrastructure is necessary. Moreover, to accommodate the unique requirements of small and mid-sized enterprises the supporting technical infrastructure must have a lower cost of ownership relative to existing solutions. The thesis of this research agenda posits that the convergence of service-oriented architecture and cloud computing, delivering a cloud-based service-oriented infrastructure, offers a comprehensive and cost-effective approach for mid-sized enterprises to establish business models using a services-based approach to business partner integration. In general terms, a cloud-based service-oriented infrastructure is the application of service-oriented principles in infrastructure or an architecture that defines the IT infrastructure in terms of services (The Open Group, 2009). In more technical terms, a cloud-based service-oriented infrastructure integrates service-enabled business functions (i.e. applications, processes, services, and data) into the underlying IT infrastructure and assets (i.e. servers, networks, storage, and software) in an automated manner (The Open Group, 2009). The evolution of service-orientation in infrastructure provides a more flexible and abstracted infrastructure layer that will enable firms to transition towards a service-oriented enterprise (Chang et al., 2006). In this study, the cloud-based service-oriented infrastructure provides the platform to enable the seamless integration of internal business processes with those of a network of business partners and providers (Beimborn et al., 2008; Dimitrakos et al., 2010; Erl, 2012).

Historically, larger enterprises purchased and deployed expensive and complex service-oriented infrastructure solutions to address internal integration requirements (Castro-Leon et al., 2008; Feuerlicht and Govardhan, 2009). These service-based infrastructure solutions are referred to as "middleware" technologies and solutions such as enterprise application integration (Mahmood, 2007; Yu and Wang, 2009; Lui et al., 2011), an enterprise service bus (Papazoglou and Heuvel, 2007; Welke et al., 2011), or SOA backplane (Haines and Haseman, 2009; Lheureux, 2011). Traditionally, these enterprise integration solutions were delivered as products and deployed on-premise. The evolution of cloud computing and "application of service-orientation to infrastructure", these types of capabilities can now be offered as-a-service (The Open Group, 2011). In particular, in the form of an integration Platform-as-a-Service delivering enterprise-class integration capabilities using cloud computing delivery models (Pezzini and Lheureux, 2011; Hetzenecker et al., 2012).

The term "Cloud" is a metaphor for a network of computing resources accessible over the Internet and represents an abstraction of complex infrastructure which is concealed from the end-user (Sultan, 2010). The term "cloud computing" represents a style of computing where dynamically scalable resources are provided "as-a-service" through internet-enabled technologies (Liu et al., 2011). The National Institute of Technology (NIST) defines cloud computing as a model consisting of five essential characteristics (on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service), four cloud deployment models (e.g. private, public, hybrid, and community), and three delivery models (e.g. software-as-a-service, infrastructure-as-a-service, and platform-as-a-service) (Mell and Grance, 2011). Wyld (2009) defines a cloud computing platform as a model that enhances the reliability, scalability, performance and configurability, delivered at relatively low cost as compared to the dedicated infrastructures.

The convergence of service-oriented infrastructure and cloud computing is a relatively new phenomenon that was first introduced by The Open Group in 2011 in their Service-Oriented Cloud Computing Infrastructure (SOCCI) framework document (The Open Group, 2011). They define SOCCI as a service-oriented, utility-based, scalable on-demand infrastructure that supports the essential cloud computing characteristics and service deployment models. The SOCCI framework advocates a service-oriented architecture and the "underlying cloud infrastructure" for implementing and managing an agile and re-usable infrastructure over the Internet. The SOCCI framework suggests that the combination of a service-oriented architecture and cloud computing provides unique characteristics and potential synergies.

Given the emergent nature of this topic, there is no scholarly research on the convergence of a service-oriented architecture and cloud computing. There is recognition in the literature that most existing cloud infrastructures have not fully adopted the SOA that would make them more flexible, extensible, and reusable (Zhang and Zhou, 2009; Lawler and Joseph, 2010). A number of thought leaders in the application of enterprise SOA initiatives (Fingar, 2009; Linthicum, 2009; Marks and Lozano, 2010) have investigated the potential synergies between service-oriented architecture and cloud computing. They argue cloud computing offers the potential for enhanced enterprise agility through the rapid provisioning of new business capabilities, but Cloud relies upon a service-oriented architecture to extend these capabilities outside the enterprise firewall. Scholars have called for research to understand the business benefits from the convergence of SOA and Cloud (Lawler and Joseph, 2010; Tsai, et al., 2010) and implications on the information technology function (Suo et al., 2011).

2.2.6 Architecture of the Service-Oriented Enterprise

Building upon the literature presented in this chapter, figure 2 represents the high-level architecture of the service-oriented enterprise. The illustration has two main objectives. First, to summarize the literature and integrate the concepts presented as the components necessary for the realization of the service-oriented enterprise. The second objective is to position the design science research methodology in two design phases as the foundation for the remainder of the literature review and the Research Design and Methodology Chapter.

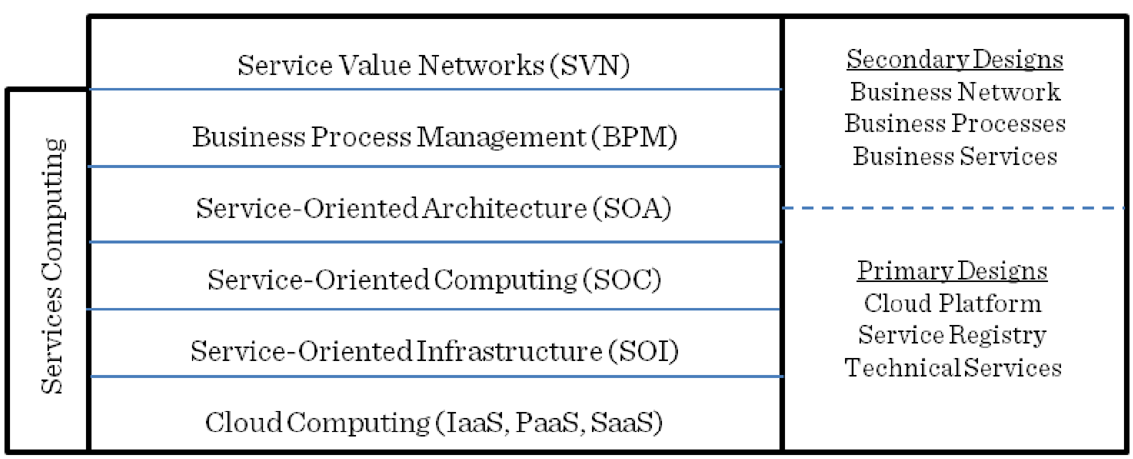

Figure 2. Architecture of the Service-Oriented Enterprise (SOE)

The service-oriented enterprise is considered the future model of the enterprise (Vitharana et al., 2007; Janssen, 2008; Poulin, 2009). As presented in the literature review, the service-oriented enterprise pursues the alignment of business services with technology services to achieve higher levels of business process agility beyond the boundaries of the enterprise. The combination of service-orientation and business process management has the potential to empower enterprises to automate and optimize service value networks through adaptable business processes (Faouzi, 2005). The main objective of the service-oriented enterprise is to enable the formation of a dynamic service value network (e.g. system of service systems) consisting of partners that possess complementary skills, knowledge, and capabilities that collectively offer customers with new and compelling value propositions. The service value network is enabled through the application of the principles of service-computing to help integrate business partner processes, services, and data with those of the enterprise.

A service-oriented architecture enables the transition towards a service-oriented enterprise (Cherbakov et al., 2005). Service-oriented architecture provides the framework, managerial policies, and technical principles (i.e. services that are modular, sharable, and loosely-coupled) to enable business process composition and orchestration independent of the underlying technology (Marks and Bell, 2006). Service-oriented computing leverages a repository of business services to develop distributed software applications based on the principles of service-oriented architecture (Papazoglou et al., 2006). The service-oriented infrastructure defines the technical infrastructure in terms of services and enables service execution (Demirkan and Goul, 2006). At this foundational level, cloud computing provides the on-demand, scalable, and virtualized computational resources offered in service delivery models

(Mell and Grance, 2011) represented as a service-oriented infrastructure-as-a-service (The Open Group, 2011).

Another perspective of figure 2 is the application of service-orientation from the technology level upwards towards the business strategy level, guided by a service-oriented architecture and enabled by the paradigm of services-computing. As described, the objective of service-orientation is to promote business process agility through the alignment of business and technology by abstracting the complexities of the underlying service-oriented infrastructure (Sultan, 2010). This notion is central to the studies research question and the use of design science research to create and demonstrate a novel approach to enable business partner integration and the formation of dynamic value networks. This studies approach to design science research embraces the view that emerging cloud platforms have multiple design phases consisting of a primary phase and secondary phases (Germonprez et al., 2011). The initial or primary design phase pursues a cloud platform that delivers capabilities in the form of services which are leveraged by the enterprise to conduct secondary designs in the context of their unique business requirements (Hovorka and Germonprez, 2011).

In this study, the primary design phase addresses the lower levels of the service-oriented enterprise architecture. At this level, the convergence of a service-oriented architecture and cloud computing delivers a “service-oriented infrastructure-as-a-service” and provides the foundation for the agility in business process composition and orchestration in secondary design phases. The overarching design philosophy in the primary phase is that the service-oriented infrastructure abstracts the underling technical complexities from the enterprise users by making business services discoverable and accessible regardless of their location, structure, and context (Vitharana et al., 2007; Montealegre et al., 2008).

In the secondary design phase, enterprise users discover, select, and integrate business services to create multi-enterprise business processes. A number of researchers argue this type of secondary design activity represents a conceptual shift from the use of pre-defined systems and applications towards a service-oriented perspective (Vargo and Lusch, 2006; Montealegre et al., 2008; Hsu, 2009; Chen and Vargo, 2010). In particular, a shift towards a service-oriented approach to design that enables enterprise users to select and integrate services in the ongoing creation of multi-enterprise business processes in the context of the firm's unique business requirements. Several of these researchers argue further that design science research in information systems is in need of new methods and models that advance the understanding and adoption of secondary design activities that encourage innovation, embrace indeterminacy of the design outcome, and integrate the customer as a co-creator in design processes (Vargo and Lusch, 2006; Chen and Vargo, 2010).

2.3 Emergence of Cloud Service Brokerage

The transition towards a service-oriented enterprise promises transformational business benefits but also presents significant complexities and adoption challenges (Vitharana et al., 2007; Basole and Rouse, 2008; Luthria and Rabhi, 2009). The service-oriented enterprise its service value network involves complex combinations of business-to-business (B2B), business-to-consumer (B2C), application-to-application (A2A) relationships, and a growing number of cloud-based services (Basole and Rouse, 2008; Lheureux et al., 2011). Inter-firm collaboration is increasing as information dependencies have grown exponentially over the last thirty years (Drecun, 2005) and is expected to double during the period of 2010 through 2015 (Biscotti, et al., 2011). Moreover, each time a business partner is added to the network, complexity can increase by an order of magnitude (Demirkan and Goul, 2006).

The increasing number, types, and complexity of inter-firm partnerships and collaborations has led to the emergence of new types of intermediaries or brokers (Cherbakov et al., 2005; Lheureux et al., 2011). The notion of intermediation and brokerage has its roots in economic literature and the *Intermediation Theory of the Firm* (Spulber, 1999, Spulber, 2003). In this literature, "intermediaries" coordinate and arbitrate transactions between a network of suppliers and customers, whereas "brokers" provide value-added intermediation services without owning the goods being transacted (Simchi-Levi and Wu, 2004).

Scholars have debated the potential of the Internet ("Cloud") to cause disintermediation (e.g. the removal of an intermediary or a broker from a transaction) of traditional entities (Wigand and Benjamin, 1996) and the emergence of new types of intermediaries (Kalakota and Whinston, 1997). Crowston (1996) argues that intermediaries will remain essential in the conduct of internet-enabled commerce and only the type or form of intermediation changes, also known as reintermediation. In this case study, the cloud services brokerage model represents a new type of intermediation model that is cloud-centric and has emerged in response to a growing demand to integrate a proliferating number of cloud-based services (Habib et al., 2010; Nair et al., 2010; Lheureux et al., 2011).

The notion of cloud service brokerage is central to this research agenda. The emergence of cloud service brokerage as a business model has the potential to enable Mohawk's transition to a service-oriented enterprise by helping manage the complexity of traditional and cloud integration requirements. The notion of cloud service brokerage is a nascent and evolving concept. In September 2011, the National Institute of Standard and Technology (NIST) incorporated the notion of a cloud broker as one of the five actors in their cloud computing taxonomy (Lui et al., 2011). They define a cloud service broker as an entity that manages the use, performance, and delivery of cloud services and negotiates relationships between cloud providers and consumers. Gartner defines cloud services brokerage as an intermediation model for business technology initiatives that are cloud-centric (Lheureux et al., 2011). Further, they define a cloud service broker as an entity that that adds value to one or more cloud services on behalf of one or more consumers of those services. Cloud service brokers provide a range of value-added services such as aggregation (e.g. combining cloud services), integration (e.g. any combinations of cloud and on-premise integration of data, services, and processes), and customization of cloud-based services (Habib et al., 2010; Nair et al., 2010; Lheureux et al., 2011). Khanna et al. (2012) argues there is a "serious void in interoperability between cloud solutions that are not been addressed by the present generation of brokering service providers, either due to technological incompatibilities or due to managerial issues."

In December 2011, the Internet Engineering Task Force (IETF) published a draft technical document to introduce the notion of a cloud broker (Shao et al., 2011). In this technical draft, the IETF adopted the NIST definition of cloud brokers and introduced the notion of an Inter-Cloud Service Broker (ISB) as an important and emergent component of the cloud ecosystem.

Inter-Cloud research is still in its infancy and the body of knowledge in the area has not been well defined (Grozev and Buyya, 2012). NIST defines an inter-cloud service broker (ISB) as an entity that facilitates the interconnection between two or more cloud service providers. According to the IETF, an inter-cloud service broker accommodates use cases where one (or more) of the interconnected entities receiving brokering services is a cloud service user. A cloud service user (cloud requestor or consumer) can be web services, applications or users (enterprise or public).

The emergence of the notion of an inter-cloud service broker is in response to the growing complexity of the enterprise computing environments consisting of multiple interconnected cloud service providers. Deloitte describes this emerging phenomenon as "hyper-hybrid clouds" where leading organizations have moved from "cloud-to-clouds" (Deloitte, 2012). They argue that this transition creates new opportunities, but presents many challenges, including integration with enterprise systems, security, data integrity and reliability, and business-rules management. Deloitte suggests that "cloud brokers may eventually emerge to deliver bundled, composite business capabilities that meet end-users' needs while hiding the complicated plumbing for integration, orchestration, and rules management." In their report entitled "*Tech Trend 2012: Elevate Information Technology for Digital Business*" Deloitte described Mohawk and the outcomes form this research study as "a lesson from the frontline in the world of hyper-hybrid clouds by leveraging an approach that combines on-premise enterprise assets with multiple cloud-based services using an enhanced set of technology disciplines" (Deloitte, 2012).

2.4 Literature Review Summary, Research Question and Agenda

In this section, a summary of the literature review is presenting leading to the presentation of the study's research question (section 2.4.1). The discussion follows with an introduction to design science research in information system as the methodology to be employed to answer the research question (section 2.4.2). The literature review chapter concludes with a summary of the research agenda and expected outcomes and contributions from the study (section 2.4.3).

2.4.1 Summary of the Literature Review

The objective of this literature review is to define key terms and definitions, to provide the context for this research study, and to demonstrate the potential significance of the research outcomes. This research is positioned in the context of a medium-sized manufacturing firm transitioning from a goods-orientation towards service-orientation as an aligned business and technology strategy. The transition towards a service-oriented enterprise embraces the notion that in a digitally connected service economy customer value is enhanced through a network of partners with complementary skills and capabilities. In the context of this study, customer value is delivered through innovative product and service bundles. The goal of the service-oriented enterprise is to achieve higher levels of enterprise agility, defined in this study as the ability of the firm to respond to changing customer demands by integrating the internal business processes of the enterprise with those of a network of external business partners.

As presented in this literature review the transition towards a service-oriented enterprise is enabled through the adoption of services-computing as an aligned approach in the business and technology domains. The paradigm of services-computing provides the foundation for flexibility and agility by leveraging service-orientation in architecture, computing, and infrastructure. Services-computing is the key enabler for the design and delivery of multi-enterprise business processes that seamlessly integrate internal business processes with those of a network of partners. Cloud computing has importance in this research study from several perspectives. First, to address the requirement for firms to effectively orchestrate the growing number of cloud services into their enterprise business processes. Secondly, a motivation of this research is to explore the potential of "the Cloud" to deliver a service-oriented infrastructure as a business technology platform to enable flexible, agile, and cost effective multi-enterprise business process integration.

This research study embodies a number of concepts that are emergent and interrelated. Thus, an objective of this literature review is to establish a foundational understanding of key terms and concepts. The terms "service" and service-orientation" were defined based on a review of the available scholarly literature. In the literature, and in the context of this study, these terms were found to have duality in meaning. The term "enterprise agility" is often-used in the context of service-orientation and cloud computing, but lacks specificity and clarity in the available scholarly literature. Thus, for the purposes of this study, the term "business process agility" is defined as the capability of the enterprise to dynamically modify and reconfigure their business processes from a broad range of business process capabilities to accommodate both known and potential needs of the enterprise. Business process agility is operationalized in terms of the range of business technology capabilities and the speed to configure and deploy these capabilities.

The preponderance of this literature review was dedicated to informing the notion of a service-oriented enterprise. At the macro-level, a service-oriented enterprise is positioned in the context of a digitally connected service economy and as the "epicenter or hub" of a network of business partnerships. As a business strategy, the service-oriented enterprise aligns business and technology efforts to extend business processes beyond the enterprise as a means to offer customers with value-added products and services. At the tactical level, the service-oriented enterprise is enabled by the paradigm of services-computing, which can be decomposed into components of architecture, computing, and infrastructure. It is at this level, with the emergence of cloud computing and its convergence with a service-oriented architecture, that represents the core thesis of this study. In particular, that a cloud-based service-oriented infrastructure delivered as-a-service complemented with a cloud services brokerage intermediation model can deliver enhanced levels of business process agility in a medium-sized manufacturing enterprise.

Thus, with the organizational context of the case study environment presented in Chapter 1 and the applicable scholarly literature presented in Chapter 2, the research question is presented as follows: how does a cloud-based architecture enable business process agility in a medium-sized manufacturing enterprise? The remainder of the literature review chapter introduces design science research in information systems as the methodically approach to inform the research agenda and answer the research question.

2.4.2 Introduction to Design Science Research

Design science research has been conducted under many different rubrics to include action science, action innovation research, participatory action research, participatory case study, and academic-industry partnership (Holmström et al., 2009). This case study is positioned in the realm of information systems research and at the confluence of people, organizations, and technology (Davis and Olson, 1985; Lee, 1999). The research question is focused on the design and implementation of an information technology-based artifact for the purposes of improving organizational performance (March and Storey, 2008). Thus, answering this research question is a design-based, problem-solving question grounded in the paradigm of design science research in information systems. The importance of design is well recognized in the IS literature (Winograd, 1997; Glass, 1999) arguing the relevance of IS research is directly related to its applicability in design (Benbasat and Zmud, 1999). There has been significant growth in interest in design science research in information systems during the past decade (McKay and Marshall, 2008). According to Hevner and Chatterjee (2010), design science is highly relevant to information systems research because it addresses two of the primary issues of the discipline. In particular, the role of the artifact in information systems research (Weber, 1997; Orlikowski and Iacono, 2001; Benbasat and Zmud, 2003) and the perceived lack of professional relevance of information systems research (Benbasat and Zmud, 1999; Hirschheim and Klein, 2003).

In the information systems literature there are two main streams of design science research. The first and more dominant focuses on the development of novel IT artifacts (Hevner et al., 2004; Vaishnavi and Kuechler, 2007; Hevner and Chatterjee, 2010) and the second focuses on IT artifact design (Walls et al., 1992; Gregor and Jones, 2007). The former perspective is influenced by the research of Hevner et al. (2004) and has been characterized as technology-centric (Germonprez et al., 2011), strongly positivist (McKay and Marshall, 2007), and a product-centric view of design (Marxt and Hacklin, 2005). In contrast, other design science researchers argue that because the design of the IT artifact is embedded in organizational context, design science research in information systems should be underpinned by a more socio-technical view (Baskerville et alt., 2007; McKay and Marshall, 2008; Germonprez et al., 2011). This perspective argues that design science research in information systems should focus on the development of valid and practical knowledge for the design of the novel IT artifact, and also for IT governance and management (Carlsson et al., 2010). Moreover, researchers argue that design science research in information systems in not only about designing a novel IT artifact to solve an organizational problem, but also about conducting research into some dimension of the design activity to solve a particular problem (Niehaves, 2007; McKay and Marshall, 2008).

In contrast to the “product view of design”, there is “process view of design” represented by a series of thoughts and activities by which an IT artifact is created and realized (Andreasen et al., 2002). This view is consistent with Walls et al. (1992) who argues that in design science research “design” is a product (artifact) and process (set of activities) – a noun and a verb. The broader perspective of design science research in information systems, beyond a focus on the design of a novel IT artifact, towards making meaningful contributions to the knowledge base of design, is represented in this study as the pursuit of an emerging service-oriented approach to business process design and execution.

According to the literature, a second challenge to address when employing design science research in information systems is the perceived lack of academic rigor and professional relevance (Benbasat and Zmud, 1999; Hirschheim and Klein, 2003). Fundamentally, the objective of design science research in information systems is to develop valid and practical knowledge that can be used by IS professionals to design solutions to known organizational problems (Van Aken, 2005; Gregor, 2006; Carlsson et al., 2010). According to Hevner and Chatterjee (2010) the primary difference between professional design and IS design science research is the nature of the problems and their solutions. Specifically, professional design involves the application of existing knowledge to organizational problems, whereas design science research addresses important unsolved problems in unique or innovative ways. The main differentiator between professional design and design science research is the clear identification of a contribution to the scholarly and practitioner knowledge base of design and communication of the contribution to the appropriate audiences (Hevner et al., 2004; Järvinen, 2007). According to Pervan and Arnott (2005) the primary differentiator between professional design and design science research in information systems is the rigorous and convincing evaluation of the IT artifact designed and developed. They argue most of the design science research focuses on the instantiation without an attempt at evaluation, and thus represents the "biggest weakness" of design science research. Iivari (2007) agrees and further emphasizes that the "essence of design science in information systems lies in the scientific evaluation of artifacts."

Hevner et al. (2004) offers guidelines for conducting and evaluating design science research. As summarized in table 2 below, design science research in information systems requires the creation of an innovative IT artifact (Guideline 1) for a specified organizational problem (Guideline 2) that is thoroughly evaluated (Guideline 3) to demonstrate that the artifact addresses a known problem in a new or more effective manner (Guideline 4). The artifact must be rigorously defined and represented (Guideline 5) to include the search process leading to the solution (Guideline 6), and the results of the design science research must be communicated effectively to technical and managerial audiences (Guideline 7).

#	Guideline Name	Guideline Description
1	Design as an Artifact	Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
2	Problem Relevance	The objective of design science research is to develop technology-based solutions to important and relevant business problems.
3	Design Evaluation	The utility, quality, and efficacy of a designed IT artifact must be rigorously demonstrated via well-executed evaluation methods.
4	Research Contributions	Design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, or design methodologies.
5	Research Rigor	Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
6	Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying the laws in the problem environment.
7	Communication of Research	Design science research must be presented effectively to both technology-oriented and management-oriented audiences.

Table 2. Design Science Research Guidelines (Hevner et al., 2004)

In response to the critique of the 2004 *MIS Quarterly* research brief by design science research scholars (Hevner, 2007), several extensions to the design science guidelines were established (Hevner and Chatterjee, 2010). Most notable of these is the view of design science research in information systems as three interrelated research cycles (Hevner, 2007). As depicted in figure 3, the design cycle is the core of design science research in information systems. The design cycle iterates between the development of an IT artifact and evaluation and subsequent feedback until a satisfactory IT artifact is realized (Simon, 1996). The relevance cycle connects the design solution to the environment by providing requirements on the design as well as testing the acceptance of the developed IT artifact. The rigor cycle seeks to ensure that the design research in information systems is grounded on theories existing in the available knowledge base and contributes new knowledge to the discipline.

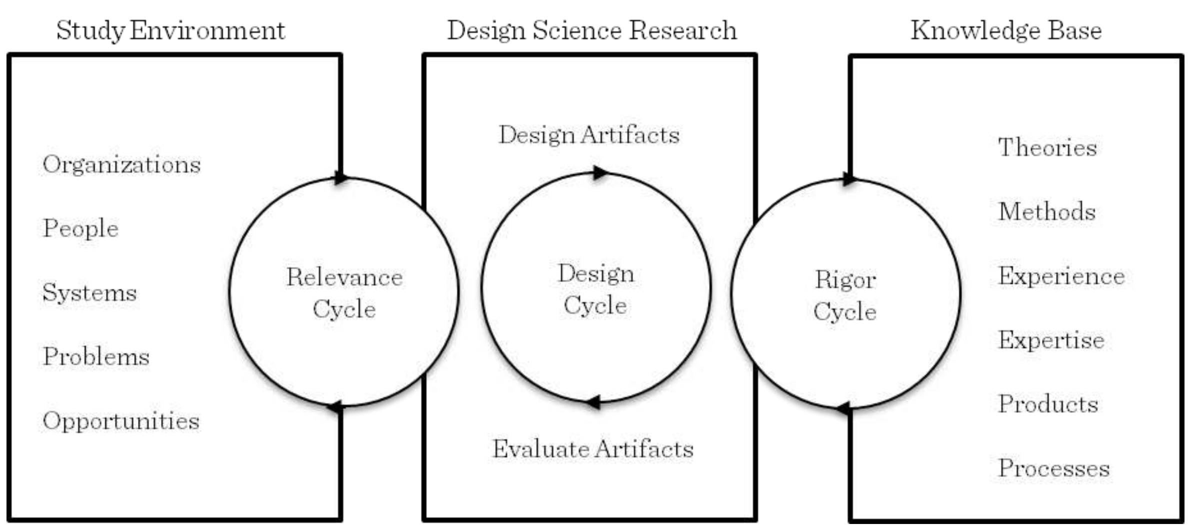

Figure 3. Design Science in Information Systems Research Cycles

2.4.3 Research Agenda and Expected Contributions

A research agenda has been presented that employs case study research and design science research in information systems to answer the research question and to inform the broader phenomenon of the service-oriented enterprise. Case study research is the most common qualitative method used in information systems research (Orlikowski and Baroudi, 1991) and is well-suited to the study information systems in organizations (Benbasat et al., 1987), particularly when the boundaries between the phenomenon under study and the context are not clearly evident (Yin, 1984). In this research, a single case study approach leverages a design science research in information systems methodology to obtain empirical evidence surrounding the service-oriented design process (Hevner et al., 2004), while capturing the contextual complexity (Benbasat et al., 1987) of a manufacturing firms transition towards a service-oriented enterprise. The research agenda pursues data collection and analysis in an iterative process (Yin, 1984; Hancock and Algozzine, 2006) consisting of cycles of design and evaluation as prescribed by the design science research in information systems process (Hevner et al., 2004). This study pursues the primary design of a cloud platform to enable secondary design activities by enterprise users, which provide evaluation and feedback to the primary design phase. The case study employs a design science research in information systems methodology developed by Peffers et al. (2007) which represents the synthesis of prior influential design research (Archer, 1984; Takeda et al., 1990; Eekels and Roozenurg, 1991; Nunamaker, et al., 1991; Walls et al., 1992; Cole et al., 2005; Hevner et al., 2004; Hevner, 2007) to collect and evaluate evidence in an iterative process consisting of six activities or phases.

Design science research in information systems seeks to invent or create a new, innovative IT artifact for the purposes of improving or solving an identified organizational problem and to communicate contributions to both academic and practitioner-based audiences (Hevner et al., 2004; Järvinen, 2007). In design science research in information systems, contributions to the scholarly and practitioner knowledge base result from both the design of an IT artifact and the design process leading to the desired solution (Walls et al., 1992).

The outcomes and contributions resulting from design science research may be classified as constructs (terms & vocabulary), models (relationships among constructs), methods (how-to-knowledge), and instantiations (March and Smith, 1995). In this study, the outcomes are expected to make contributions to the scholarly and practitioner knowledge base in each of these four categories, as summarized below.

Constructs. This research explores the transition of a medium-sized manufacturing firm towards a service-oriented enterprise as a strategy to form dynamic networks of business partnerships for the purposes of value creation. This transition is enabled by the paradigm of services computing represented by the convergence of service-oriented architecture and cloud computing. This research agenda seeks to provide insight into a number of emerging and interrelated concepts and constructs through new models and methods implemented in the case study environment. The research seeks to inform the constructs of service, service-orientation, cloud, cloud computing and how they enable flexibility and agility and offer value propositions from a business perspective in practice. Findings emerging from the research are expected to result in new terms and constructs related to the convergence of a service-oriented architecture and cloud computing as an approach to enhance business process agility in the case study environment. This research agenda addresses calls by researchers to provide insight and guidance to advance the notion of a service-oriented enterprise (Demirkan and Goul, 2006; Vitharana et al., 2007; Poulin, 2009; Alter, 2012). The study seeks to provide empirical evidence, which is lacking in the literature, that support the assertions and business benefits typically associated with the realization of service-oriented enterprise (Janssen, 2008). Scholars have called for research to understanding how this structure of the enterprise advances the discipline of Service Science and the design of service systems (Tien and Berg, 2003; Zhao et al., 2008; Wolfson et al., 2010). This research seeks to address these gaps in the literature on the actual business benefits resulting from the convergence of service-oriented architecture and cloud computing (Lawler and Joseph, 2010; Suo et al., 2011) and the absence of guidance on their deployment in medium-sized enterprises (Marston et al., 2011; Chen, 2012). Lastly, this research seeks to introduce new constructs in the realm of cloud-based business integration with emerging constructs to include business process, orchestration, choreography, and improvisation and emerging models to include Service-Oriented Cloud Computing Infrastructure (SOCCI), integration Platform-as-a-Service (iPaaS), Cloud Services Brokerage (CSB), and the Service-Oriented Enterprise (SOE).

Models. In design science research, a model is a set of statements to express relationships among constructs that represent the problem and solution situations (March and Smith, 1995). This research agenda seeks to design and demonstrate a new business model to enable the transformation of a medium-sized manufacturing enterprise by leveraging the cloud as a business technology platform and a cloud services brokerage model. Literature on the topic of cloud-based service-oriented infrastructure and cloud services brokerage only exists at the conceptual level in standards organizations (e.g. The Open Group, 2011) and governmental agencies to include the National Institute of Standards and Technology (Mell and Grance, 2011), the Internet Engineering Task Force (Shao, et al., 2011), and BEinGRID a European Union funded research program (Dimitrakos et al., 2010). The U.S. Government has described the transition towards a service-oriented enterprise "as the most challenging of the major parts of the Target Architecture because it requires the greatest change to entrenched business practices." (CIO Council, 2008).

Methods. In design science research, methods define process and the how-to-knowledge to solve problems to include textual descriptions of "best practice" approaches (Hevner et al., 2004). This research seeks to contribute to the scholarly and practitioner knowledge base through a demonstration of new design methods and approaches to deliver a cloud-based service-oriented infrastructure upon which secondary designs of multi-enterprise business processes are performed. In today's networked service economy, digital partnerships are essential for firm performance (Barringer and Harrison, 2000; Ozgur et al., 2009; Lee et al., 2010) and this research seeks to address gaps in practice to integrate and coordinate inter-organizational or multi-enterprise business processes for business value (Venkatesh and Bala. 2007). The research seeks to define and demonstrate guidelines for the design of a cloud integration platform by leveraging the principles of service-oriented architecture and cloud computing. This research seeks to address current gaps in the scholarly literature and practice to develop and demonstrate service-oriented design methods to integrate internal systems and processes with emerging types of cloud service delivery models (Feuerlicht and Govardhan, 2009; Luthria and Rabhi, 2009; Marston et al., 2011; Chen 2012). This research agenda also seeks to address the absence of literature and practical guidance on the adoption of an outside-in service-oriented architecture adoption pattern that incorporates externally provided software and services in small and medium-sized enterprises (Castro-Leon et al., 2008). Lastly, the research agenda seeks to address calls from researchers to create new design methods at the intersection of Design Science and Service Science. In particular, a service-oriented approach to information systems design that leverages business services in the ongoing creation and re-creation of systems (Germonprez et al., 2011) and embraces the notion of indeterminacy of design and involves the customer as a co-creator of value-in-context (Chen and Vargo, 2010), and enable scale in the design of digital service interactions enabling service systems (Hsu, 2009).

Instantiations. In design science research in information systems, an instantiation is the realization of the designed IT artifact in its environment and provides insight into the how it provides a solution to an organizational problem (March and Smith 1995). Instantiation is the representation of abstract concepts in an actual instance and operationalizes constructs, models, and methods. In design science, an instantiation represents a concrete realization of a construct, model, or method and enables the design researcher to "actually test their concepts under real world conditions and learn more about the real world" (Cleven et al., 2009). This research study pursues the design and instantiation of a service-oriented infrastructure and cloud services brokerage to enable the design and governance of multi-enterprise business processes. This literature review finds no scholarly research on the instantiation of a cloud business integration platform and cloud service brokerage models in practice. Several technology authors (Fingar, 2009; Linthicum, 2009; Marks and Lozano, 2010; Erl, 2012) have promoted the synergies and benefits of service-oriented architecture and cloud computing as an enabler of enterprise agility, however, these various works lacked specificity and examples of actual deployments in practice.

An early outcome of this research study, a Gartner case study on Mohawk (Lheureux, 2010), represents the first known publication on the instantiation of an integration Platform-as-a-Service (iPaaS) and Cloud Services Brokerage model to enable the design and deployment of a wide range of multi-enterprise business processes. This research agenda expands upon this work to provide insight as to how a cloud-based service-oriented infrastructure can enable the realization of a service-oriented enterprise and the formation of service value networks that integrate the competencies of the firm with those of an ecosystem of business partners and cloud service providers.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.0 Chapter Overview

This chapter presents the research design and methodology used to collect and analyze data to answer the studies research question. The goal of the chapter is to provide an explanation of the data collection procedures employed in the conduct of this research study to allow readers to evaluate the validity of the study conclusions or emulate research strategies in another setting or context. The first section of the chapter begins with brief overview of the purpose of the research study, the case study environment and participants, and a restatement of the study's research question (section 3.1). In the following section (section 3.2) an overview of design science research in information systems is provided to include the rationale for its selection and presentation of a nominal design science research process model employed in the research study. In the next section the data collection procedures used in the study are presented and explained in the context of the phases of the nominal design science research in information systems process model (section 3.3). The six phases of the design science research process model include the identification and motivation phase, the define the objectives for a solution phase, the design and development phase, the demonstration phase, the evaluation phase, and the communications phase. The chapter concludes with a brief explanation of the strategy used to analyze the data and evidence collected during the study to address the research problem and answer the research question (section 3.4) and a discussion of the limitations, validity, and reliability of the data collected and analyzed (section 3.5).

3.1 Research Design Overview

The motivation for this research was to design and implement a more effective approach to integrate the capabilities of a network of business partners and service providers with the internal business processes of the enterprise. This motivation was provided in the context of a medium-sized manufacturing enterprise requiring a business model transformation in response to distributive market forces that jeopardize the short-term profitability and long-term viability of an enterprise operating for 80 years. To address this business challenge, Mohawk pursued the design of a cloud-based business integration solution to enable the effective design and deployment of multi-enterprise business processes to form a network of business partners. The seamless integration of internal capabilities with those of external business partners resulted in the formation of service systems and service value networks that are responsive to change and offer customers with value propositions not achievable by the enterprise alone. In this context, the study pursued the research question: how does a cloud-based architecture enable business process agility in a mid-sized manufacturing enterprise? Answering this research question was fundamentally a problem solving process that required the design, demonstration and evaluation of an innovative IT artifact. In this study, the design process consisted of two interrelated design phases, a primary phase that pursued the design of a cloud integration platform and a secondary design phase. In the secondary design phase, enterprise users leveraged the capabilities of the cloud integration platform to discover and select business services for orchestration in multi-enterprise business processes and to choreograph them into unique combinations to form service systems and value networks for the purposes of customer value creation.

The research study was conducted over a two-year period from April 2010 through April 2012. The case study employed a design science research in information systems methodology to answer the research question. Mohawk, a medium-sized manufacturer of paper products provides the case study environment. Mohawk, well known for its technological innovation, partnered with Liaison Technologies to design and implement a cloud-based integration platform to enable Mohawk to transition its business strategy towards a service-oriented enterprise. As the chief information officer (CIO) of Mohawk, this researcher was an active participant and influencer of the research goals, resources, processes, and outcomes. As an “insider” or “practitioner” researcher, the study draws upon the knowledge and experiences of the participants and benefits associated with unprecedented access to contextual information about the organization under study. Other participants in the study included two information technology professionals from Mohawk and two professionals from Liaison Technologies.

Practitioner or insider research has advantages related to greater access and understanding of a context, but also presents certain disadvantages related to the potential lack of “impartiality” or “objectivity” in the conduct and defense of the research study. As an “insider” researcher, dual roles and outcomes are concurrently pursued; one as a practitioner seeking to address a particular business problem and one as a researcher seeking to apply scientific methods to make meaningful and relevant contributions to the scholarly knowledge base of design. This duality of roles presents certain questions that the researcher must consider in the conduct of the research, in the interpretation of the evidence collected, and in how the research should be evaluated by others. Questions that might arise as an insider researcher conducting case study research include are, what is the trustworthiness of the data collected, how do organizational pressures influence the research outcomes, and what is the influence of external participants such as vendors? One approach for the practitioner researcher to address potential threats to the validity of the research is to identify their own perspectives as part of the research process, thereby contextualizing findings with consideration to any possible influence or bias by the researcher (Unluer, 2012).

Providing sufficient context is important to address the generalizability of insider research conducted in a case study environment. Because the data collected is limited to the case study environment, generalizability of findings and recommendations to other settings and context is problematic. Van den Akker (1999) argues that the researcher should invest in "analytical" forms of generalization where the readers of the research need to be supported to make their own attempts to evaluate the potential transferability of the research findings to their unique context. An assessment of the trustworthiness of the evidence collected, plausibility of the research process, and transferability of the findings can be facilitated by a clear articulation of the design principles applied, the data collection and analysis methods used, and description of the research context and the perspectives of the researcher (Yin, 1994; Miles and Huberman, 1994). This methods chapter seeks to provide sufficient levels of clarity and specificity on the data collection and analysis procedures (e.g. what data was collected, how it was collected, and why it was collected). At the conclusion of the Research Methods Chapter (section 3.5) a perspective is presented as to the limitations, reliability, and validity of the data collected and analyzed during the study. Further reflection on the generalizability and transferability of the results, findings and recommendations to other context is presented in the final chapter of this thesis.

3.2 Design Science Research Methodology

A design science research in information systems (DSRIS) methodology in the context of case study research was employed to answer the research question. As presented in the Literature Review Chapter, design science research in information systems seeks to create and evaluate innovative IT artifacts intended to solve known organizational problems (Hevner et al., 2004). A design science research in information systems process model developed by Peffers et al. (2007) was selected as the methodological framework for conducting this research study. As described, the design science research in information systems process model developed by Peffers et al. (2007) represents the synthesis of prior influential design research (Archer, 1984; Takeda et al., 1990; Eekels and Roozenurg, 1991; Nunamaker, et al., 1991; Walls et al., 1992; Cole et al., 2005; Hevner et al., 2004; Hevner, 2007) and seeks to provide a "mental" model for others to evaluate the quality and applicability of design science research in information systems.

The design science research in information systems process model consists of six phases: 1) problem identification and motivation, 2) define the objectives for a solution, 3) design and development, 4) demonstration, 5) evaluation, and 6) communication. As depicted in figure 4 below, the phases of the design science research process model are presented in sequential order; however the process is iterative as design activities may be informed by feedback from the evaluation and communication phases. For the purposes of this research study, the design science research in information systems process model was modified to expand the design and development phase into two sub-phases, a primary design phase and a secondary design phase.

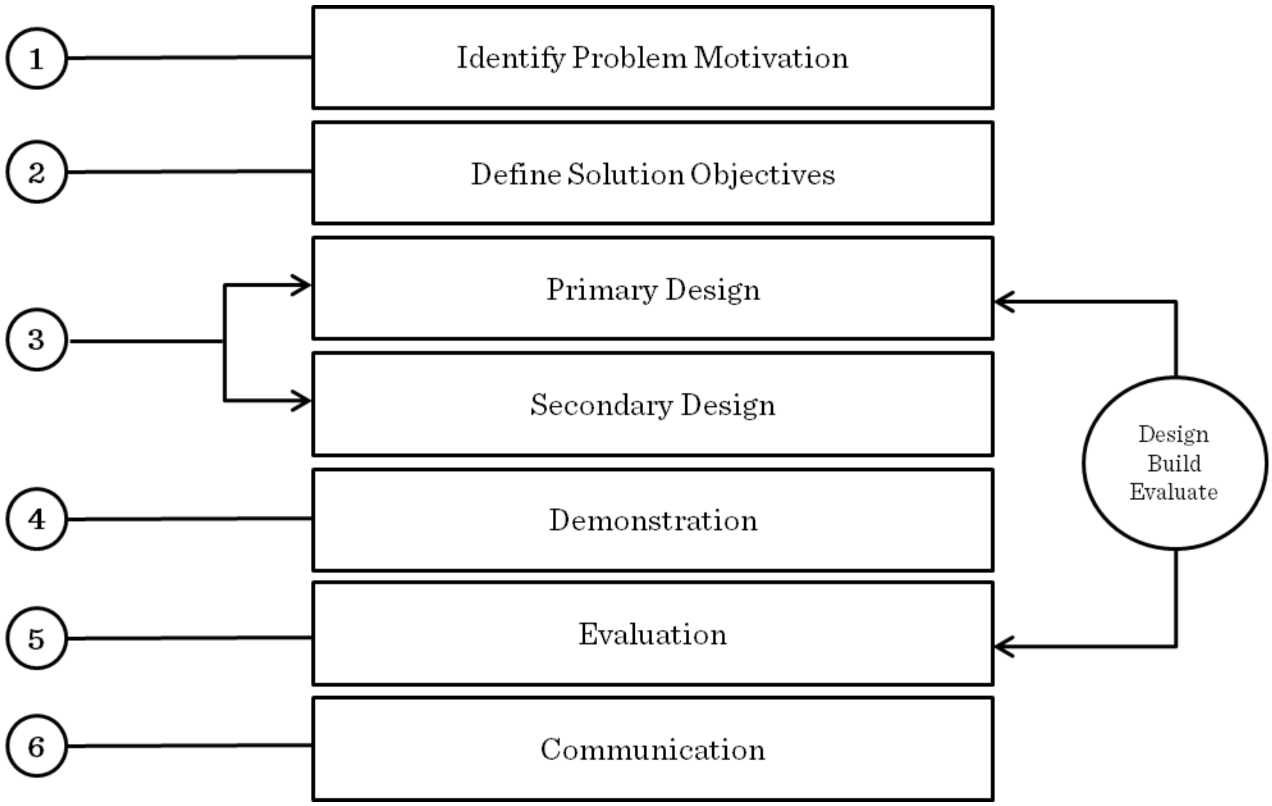

Figure 4. Design Science Research Methodology Process Model (Peffers et al., 2007)

In the following sections (3.2.1 – 3.2.6) the methodological intent of each of the six phases of the design science research in information system process model is provided in the context of this research study. In section 3.3, the data collection methods used in each of the six phases is described in more detail.

3.2.1 Problem Identification and Motivation Phase

The goal of the Problem Identification and Motivation Phase of the design science research process model is to define the specific research problem and justify the value of a solution. In this research study, the design of a cloud-based business process integration platform was pursued to address deficiencies and gaps in the solutions space. A solution was required to effectively support the agile design and rapid deployment of diverse multi-enterprise business processes in a mid-sized manufacturing enterprise. For Mohawk, the cloud-based integration platform enabled a business strategy transformation that leverages a network of business partnerships to offer new and innovative products and services to customers. This researcher was embedded in this case study setting and had direct knowledge of the state of the problem and the importance of the desired solution, which are discussed in detail in the Introduction Chapter and Literature Review Chapter of this thesis.

3.2.2 Define the Objectives for a Solution Phase

The goal of the Define the Objectives for a Solution Phase is to substantiate how the newly designed IT artifact is expected to address the business problem. For this research study, the objective of the solution was to develop and implement a cloud integration platform to enable the flexible and cost-effective secondary design of a wide range of multi-enterprise business processes. The desired solution employs a cloud services brokerage model and an integration Platform-as-Service to effectively address all known business integration scenarios (e.g. business-to-business, application-to-application, cloud-to-on-premise, and cloud-to-cloud). By leveraging the principles embodied in service-oriented architecture and cloud computing, the desired solution is expected to provide this medium-sized manufacturing enterprise with enhanced levels of business process agility, enabling a dynamic business model that leverages the capabilities and competencies of a network of business partners.

3.2.3 Design and Development Phase

The Design and Development Phase of the design science research process model seeks to determine the IT artifact's desired functionality and architecture followed by the pursuit of design and development cycles for the actual artifact. The iterative cycle of artifact design to development is core to the design science research process in information systems. In this research, the design and development process consisted of interrelated and complementary primary and secondary design activities. Primary design activities pursued the development of a cloud integration platform and supporting business and technical services. The cloud integration platform and registry of technical and business services provide the platform for secondary design activities conducted by the enterprise. These secondary designs activities pursued multi-enterprise business processes that integrated enterprise systems, processes, services, and data with those of a network of business partners. As discussed in the following two sections, the demonstration and evaluation of secondary designs deployed in the case study environment during the study period provided feedback to primary design activities in an iterative design-build cycle.

3.2.4 Demonstration Phase

The design science research in information systems process requires a demonstration of the artifacts use to solve one or more instances of the business problem. In this research study, the demonstration involved the implementation of a cloud-based integration platform and use of a cloud services brokerage model to design and deploy multiple end-to-end business processes across the boundaries of the enterprise. The design process is an iterative and incremental activity in which the demonstration and evaluation phase provides feedback to increase an understanding of the business problem and to improve the quality of the desired IT artifact and the service-oriented design process. As described, primary design activities associated with the development of the cloud integration platform pursued capabilities to enable ongoing secondary designs of multi-enterprise business processes, which in turn provided feedback to subsequent primary and secondary design activities.

3.2.5 Evaluation Phase

The goal of the Evaluation Phase is to observe and measure how well the artifact supports a solution to the problem. In this research study the solution was evaluated using quantitative and qualitative measures. The effectiveness of the cloud integration platform, as compared to prior integration techniques deployed in the case study environment, was evaluated using quantitative measures. The expected and desirable outcomes of the evaluation of the cloud integration platform would result in an increase in the rate, number, and types of multi-enterprise business processes deployed with a reduction in the overall design time and cost. The cloud integration platform was evaluated using qualitative measures in two key aspects. The first evaluated the extent to which the cloud-based integration platform adhered to the foundational design principles of service-oriented architecture and cloud computing. The second evaluated if and how well the cloud integration platform delivered new or innovative capabilities to address the defined problem in ways not previously available in the solutions space. Collectively, these quantitative and qualitative observations and measures inform the research question and exploration of how a cloud business integration platform enhances business process agility in the case study environment. In this research study, business process agility is operationalized in terms of a range business integration capabilities and the speed of deployment, expressed in both quantitative and qualitative measures of the solutions functionality, completeness, performance, and usability within the case study environment.

3.2.6 Communication Phase

The design science research in information systems process requires the communication to researchers and practicing professionals about the research problem and its importance, a description of the artifact, the rigor of the process leading to the design, and an explanation of the artifacts effectiveness to address the problem. In design science research in information systems, the presentation of the research results, findings, and recommendations must address the research rigor requirements of the academic audience as well as the relevance requirements of the professional audience.

3.3 Data Collection Procedures

In this section, the data collection methods and procedures used in the research study are presented and explained. The goal of this section is to provide sufficient detail on what data was collected, how the data was collected, and why the data was collected to help readers to evaluate the research findings and potential to replicate aspects of this research. The section begins with an overview of the research phases and timelines (section 3.3.1). Next, the sources of data and evidence used in the study are presented in the context of the six phases of the design science research in information systems process model (section 3.3.2). In the following section, the data collection methods and procedures employed in the design-demonstration-evaluation phases are presented as a step-by-step process used to collect, organize, codify, and transcribe the data from the sources of evidence used in this study (section 3.3.3).

3.3.1 Research Study Phases and Timelines

The research study spanned two-years, commencing in April 2010 and concluding in April 2012. The initial phase is represented by the Problem Identification and Motivation Phase which was conducted during the period of April 2010 through June 2010. The Define Solution Objectives Phase which was conducted during the period of July 2010 through September 2010. The Design-Demonstrate-Evaluate phase was conducted over an eighteen month period beginning in October 2010 and ending in March 2012. This phase included iterative cycles of primary design activities interlaced with multiple secondary designs and their demonstration and evaluation in practice. Throughout the research study, the research intentions, progress, and contributions to were communicated to various professional and scholarly audiences.

As described in more detail in the following sections, data and evidence in various forms were generated across the phases of the research study. The preponderance of data was collected in the primary and secondary design, demonstration and evaluations phases during the period of October 2010 through March 2012. During the primary and secondary design-build-evaluate phase, quantitative data such as type of design activity, design hours, design costs, project date milestones were collected using established standard project management instruments in use in the case study environment. This data collected during the study was organized, codified, and transcribed for subsequent analysis and presentation during the period between April 2012 and June 2012. During the period of June 2012 through April 2013 the data collected in the study was analyzed leading to a number of tables presented in Chapter 4 to illustrate key summary statistics and patterns emerging from the data.

The following sections provide detail on the sources (and types) of evidence made available during this phase to include an explanation of the variables of interest to answer the research question and the step-by-step procedures used to collect and organize the data for subsequent analysis. Figure 5 below, summarizes the research timeline and phases of the design science research in information systems model. Note that the primary and secondary design phases as illustrated below consist of iterative design-build-evaluate cycles.

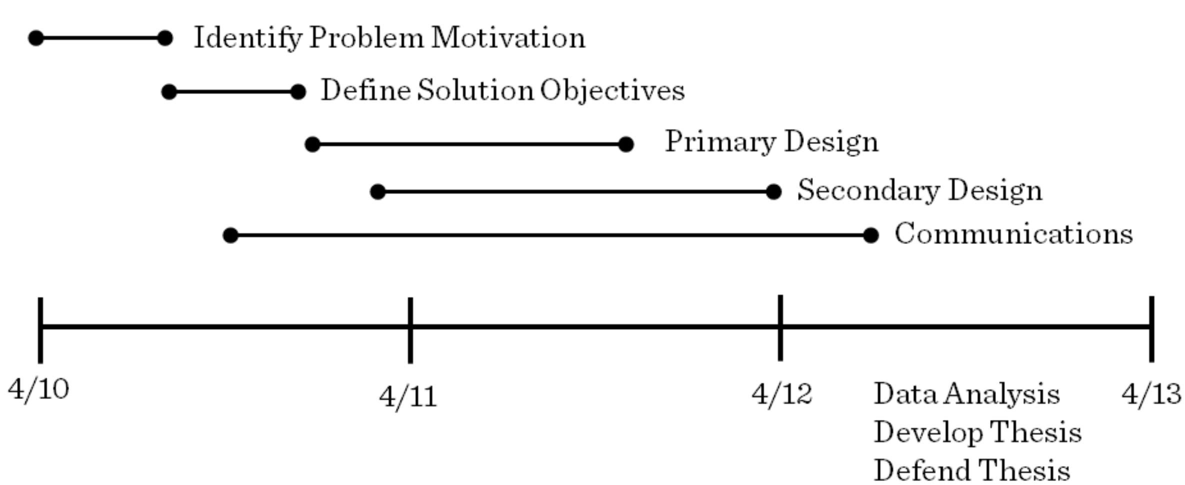

Figure 5. Design Science Research Phases and Timelines

3.3.2 Data Collection Sources of Evidence

This section describes the sources and types of pertinent data and evidence generated during each of the phases of the design science research process model. This section is organized into four phases of the design science research model. The phases are the Identify Problem and Motivation Phase (section 3.3.2.1), Define Solution Objectives Phase (section 3.3.2.2), Design-Demonstration-Evaluation Phase (section 3.3.2.3), and the Communication Phase (section 3.3.2.4). Given the direct relationship between the primary and secondary design phases and the cyclical nature of the design, demonstration, and evaluation activities, for the purposes of data collection in this study these three categories are combined in section 3.3.2.3.

3.3.2.1 Identify Problem and Motivation Phase

The importance of commencing research in general and design science research in particular (Nunamaker et al., 1991; van den Akker, 1999; Hevner et al., 2004; Peffers et al., 2007) with a clearly articulated problem is widely recognized. According to Hevner et al. (2004) research problems addressed using design science research exhibit common characteristics of having environmental factors, inherent complexity in the problem and possible solutions, flexibility and potential for change of possible solutions, a solution at least partially dependent on human creativity, and a solution partially dependent on collaborative effort. These characteristics resonate with the context and research problem presented in the Introduction and Literature Review chapters of this thesis. Namely, that business demands imposed upon the case study environment necessitated an academic-industry collaboration to design a new and innovative approach to business partner integration. In this study, the research problem can be described as the need for an approach (solution) to business partner integration that accommodates both traditional and emerging integration requirements and has a cost and support structure that is aligned with the limited technical and financial resources of a medium-sized enterprise. In practical terms, the research problem is stated as the absence of a cost-effective solution that addresses known business integration requirements. Thus, the relevance and applicability of design science research in information systems to design and to develop a technology-based solution to an important and heretofore unsolved business problem in unique or innovative way (Hevner et al., 2004). Hence, for the purposes of this study, one of the objectives of the Problem and Motivation phase is to investigate and demonstrate the gap and opportunity in the solutions space, thereby justifying the use of the paradigm of design science research in information systems to address a problem in a new and innovative way.

To address this requirement, during the period of April 2010 through June 2010, a review was conducted of available business integration solutions to identify possible alternative solutions and to validate the non-existence and novelty of the proposed technology-based artifact. The survey of the solutions landscape commenced with an internet search of business integration vendors and solutions. During a two-week period, a high-level review of business integration vendors and solutions was conducted and an inventory of solutions providers was established to include a summary of the basic capabilities of their products and services. A total of 25 vendors were identified and reviewed. Most of the solutions focused on traditional business-to-business integration solutions, others emphasized value-added networking services, and a relative few focused specifically on emerging cloud-based integration. To substantiate these high-level findings, a research report from a leading IT consulting and advisory firm focusing on business integration vendors and solution space was secured and reviewed. Their report and assessment of integration vendors and solutions supported the existence of two general categories of business integration solution providers: enterprise-class solutions and emerging cloud-based solutions. Appropriate for this study, the report categorized business integration vendors and solutions specifically targeting small and medium-sized enterprises.

Leveraging the results from the internet search of solutions providers and research report on business integration vendors and solutions, six vendors were identified as representative of the business integration solutions and candidates for further investigation on each of their capabilities and costs. The vendor solutions evaluated included two leading enterprise-class solutions from Tibco and Software AG, two emerging business integration solutions from Dell (Boomi.com) and IBM (CastIron), and two solution providers focused on serving the mid-sized market from Extol and Infor. The capabilities of each of vendor solution were evaluated through a series of product and solution demonstrations. In two cases (Tibco and Software AG) the vendors asked for our requirements and conducted a 2-3 hour demonstration of their products and solutions at the case study environment. In two other cases (Dell and IBM), a 1-2 hour webinar was conducted to demonstrate their functionality. In the remaining two cases (Extol and Infor), no product demonstrations were conducted as both solutions were installed and operational in the case study environment. The four business integration vendors that provided on-site or on-line demonstrations provided formal proposals with the total purchase cost of their solutions and consulting services to fully implement the solution in the case study environment. Four members of the Mohawk information technology (IT) team (including this researcher) participated in the two on-site product demonstrations and two on-line webinars. In addition to product information provided by the vendors, each member of the evaluation team transcribed notes on what each individual believed to be the salient points discussed and presented during the product solution demonstrations. Information considered as important to capture during these demonstrations included the capabilities of the solution (e.g. what integration use cases were supported), the complexity of deploying these capabilities relative to the existing internal skills and knowledge, and the purchase or license costs for the various modules necessary to support the current and future business requirements.

To guide the collection and reporting of the evaluations team's perspectives of the strengths and weaknesses of the solutions as a match to Mohawk's requirements, a vendor solution matrix was developed. The vendor solution matrix evaluated capabilities and functionality across the four integration use cases required in the case study environment (e.g., business-to-business, application-to-application, cloud-to-on-premise, and cloud-to-cloud). In addition, the vendor solutions were evaluated on the purchase cost and internal skills and resources necessary to effectively deploy and manage the solution.

The vendor solutions were evaluated in three categories: purchase cost, solution complexity, and technical capabilities across four integration use cases. Assessments in each category were provided a rating scale from 1 to 5 (1-Poor, 2-Fair, 3-Average, 4-Good, and 5-Excellent). A rating score of zero (0) indicated the vendor solution does not provide this capability. The technical capabilities score is represented by the average of each of the four use case ratings (A2A, B2B, C2P, and C2C). The overall score is represented by the weighted average of cost

(30%), complexity (30%) and technical capabilities (40%). The criterion used for evaluating cost was based on the original purchase cost, the ongoing software license and maintenance costs, and any hardware costs associated with hosting the solution. Solution complexity was evaluated based on internal support requirements and the expected time-to-deploy business integration solutions. Technical capabilities were evaluated based on the functionality and effectiveness of the vendor solution to address all business integration use cases (A2A, B2B, C2P, and C2C). A rating score of 3 (average) was deemed to be the minimally acceptable standard. Any individual or overall rating score lower than 3 was deemed to be unacceptable and a disqualifier for the solution to effectively address the business requirement. Presented below in table 3 is the vendor solution matrix used to collect and report the team overall scores of the comparative capabilities of the six vendor solutions.

	Purchase Cost	Solution Complexity	Technical Capabilities			
			A2A	B2B	C2P	C2C
Dell Boomi.com	(1-5)	(1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)
IBM CastIron	(1-5)	(1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)
Tibco	(1-5)	(1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)
WebMethods	(1-5)	(1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)
Extol	(1-5)	(1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)
Infor	(1-5)	(1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)	(0, 1-5)

Table 3. Vendor Solutions Evaluation Matrix

A team of Mohawk information professionals, who participated in the product demonstration, including this researcher, provided their assessment of the six vendor's overall capabilities. Each member of the evaluation team was advised of the evaluation categories and meaning of the rating score. In a one-hour meeting, the team provided their individual rating score based on their recollection, notes from the demonstration, and formal solution proposal, for each of the evaluation categories. For each vendor, the team deliberated and reached consensus on the overall rating in each evaluation category. There was minimal subjectivity on the solution purchase and implementation cost (a fixed number) or the capability of the vendor to support a particular business integration use case (they did or did not). Most of the subjectivity in the evaluation centered on the rating for solution complexity, as there was different perspectives within the team resulting from their particular roles and experiences. In this case, the average rating from each of the team members was captured. The results from the overall evaluation were collected and transcribed in the vendor solution matrix during the meeting, all evaluation members provided their approval of the overall results (rating).

3.3.2.2 Define Solution Objectives Phase

The intent of the Define Solution Objectives Phase is to infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible. This phase requires definition as to how and why the desired IT artifact will be more effective at addressing the research problem than are existing solutions and approaches. In this study, the research question examined how the design of an innovative IT artifact (a cloud integration platform) enhances business process agility in the case study environment. Enhanced levels of business process agility can be expressed in quantitative terms (e.g. faster and more cost effective than current solutions) and in qualitative terms (e.g. how the desired artifact is expected to support business integration in a new or different way). As described in detail later in this methods section, the quantitative measures such as dates and the number of hours and cost to design and deploy multi-enterprise business processes using the new artifact in comparison to prior methods is relatively straightforward with respect to data collection, data analysis and the presentation of results. Whereas in qualitative data collection and analysis, particularly when pursuing a formative design process, involves an iterative set of processes exhibiting a "loop-like pattern of multiple rounds of revisiting the data as additional questions emerge" (Miles and Huberman, 1994). In this study, the iterative process of evaluating the uniqueness, novelty and effectiveness of the desired IT artifact began with the establishment of the core design objectives. Specifically, a set of design principles and guidelines that leverage the benefits of service-oriented architecture and cloud computing resulting in a cloud business integration platform to enable more effective business process integration with business partners.

During the period of July 2010 through September 2010 two engagements were pursued to establish the design framework based on the principles of service-oriented architecture and cloud computing. The first engagement was a two-day working session with representation from Mohawk and Liaison Technologies. The goal of this session was to define and agree upon the service-oriented architecture principles that would guide the design activities. The core design principles embraced the notion of representing business functionality as business services, ensuring loose-coupling for interoperability across diverse technology platforms, and to leverage the re-use of business services to increase speed of deployment and reduce design and development costs. During the working session, a scribe was assigned to the project team to document the discussions and capture the agreed upon principles and guidelines. A draft document was established during a two-day working session and provided to team members (three Mohawk employees and three Liaison employees). Over a period of several weeks, the document was reviewed and refined by the entire project team to provide further clarity and specificity. The outcome from this engagement was a ten page document "SOA Manifesto: Guiding Design Principles for a Cloud-Based Service-Oriented Infrastructure."

The second engagement was conducted during a two-month period with representation form Mohawk and AgilePath. The primary objective of this engagement was to define the essential characteristics and attributes of a services-based cloud computing deployment model and to establish reference architecture to help guide the design of a cloud-based service-oriented infrastructure. The engagement leveraged the experience and expertise of AgilePath to help formulate a reference model for the cloud architecture. The document was a reviewed and discussed by the project team and several revisions to the document were executed, primarily to further emphasize the role of service-oriented architecture and the unique requirements of a mid-sized enterprise. The outcome and deliverable from this engagement was a seventy-page document entitled "Cloud Computing Reference Model: Accelerating Mohawk's SOA-in-the-Cloud Transformation."

These two documents (SOA Manifesto and Cloud Computing Reference Model) provided the technical details necessary to design and deliver a solution based on the principles of service-oriented architecture and cloud computing. To be useful for the purposes of guiding the design process and evaluation of the resulting IT artifact(s) adherence to these requirements, the documents needed to be synthesized into salient and high-level design principles. During the month of September 2010, this researcher reviewed the two documents to identify the salient points and to reduce or distill the qualitative data into a more useable form. As the design principles emerged, they were documented in a worksheet entitled "Guiding Principles" and distributed to the project team for validation and comment. After multiple iterations and discussion the salient points derived from the two documents, ten (10) guiding principles were established and are presented in the Chapter 4 (Findings and Results) of this thesis.

3.3.2.3 Design-Demonstration-Evaluation Phase

The iterative cycle from design to demonstration to evaluation is core to the design science research process. In this study, the design-demonstration-evaluation process consists of two interrelated primary and secondary design activities. Primary design activities encompassed the development of the cloud integration platform and repository of reusable business services and supporting technical services. The cloud integration platform and registry of business and technical services provided the foundation to enable the enterprise to conduct secondary designs. The secondary designs pursued multi-enterprise business processes for the purposes of integrating partner capabilities with Mohawk's enterprise systems, processes, services, and data. The output of the primary design activities enable secondary designs conducted in the unique context of the enterprise and provide feedback to the primary design activities in an iterative cycle.

The design-demonstration-evaluation phase encompasses the design and development of an IT artifact, leading to the demonstration solve an instance of the problem, to a more formal evaluation of how well the artifact supports the solution to the identified problem. The design-demonstration-evaluation phase was conducted during an 18 month period between October 2010 and March 2012. During this phase, data detailing the design, demonstration, and evaluation of primary and secondary design activities were collected using standardized project management procedures and templates instituted in the case study setting for more than a decade. Two project management instruments were used to collect data during the primary design and secondary design phases, a technical specification document and a project planning template. A technical specification and project planning template was established for each of the primary design phases (a total of 6) and each of the secondary designs (a total of 39 prior to the study and 56 during the study). The technical specifications and project planning documents were established by the assigned project manager from Mohawk at the start of the design task and maintained until the task was completed. No material changes were made to the pre-instituted technical specification or project planning documents to accommodate the data collection requirements of this research study.

The project planning document is a single page template designed to track and report project milestones and costs. Quantitative data collected using this document included a unique project identifier, planned and actual design time, the planned and actual design cost, and the project start, evaluation (testing), and demonstration (implementation) dates. The planned design hours and planned cost estimates vary if the design activity uses an existing business services or is a new design activity. The actual design and development costs were provided by the cloud services broker (Liaison). The project planning document also included the project manager, a description of the project or design task, and the collaborating business partner, if applicable.

The technical specification document also includes the unique project identifier, the assigned project manager, and the name and type of the business partner (if applicable). The technical specifications include data about the originating business services (S_O) and the terminating business service (S_T), which are orchestrated to establish a service interaction and business process. This includes data such as the type of business service, its owner (internal, partner, or cloud provider), and if it's a new business service reuse of an existing business service. The technical specification is a 2-3 page document consisting of data described above and several paragraphs that elaborate on the project objectives and technical requirements. The richness of the technical specification document resides in the description of the project objectives and the technical requirements necessary to achieve these objectives. In this study, the technical specifications for the design activity include details such as the service invocation method, the communications protocol, the canonical type, any data transformation, and the type of service interaction or multi-enterprise business process use case (e.g. A2A, B2B, C2P, and C2C). In six instances, the secondary design phase informed the primary design phase, requiring new or enhanced cloud integration platform functionality to support a new type of multi-enterprise business process requirements. These occurrences were noted on the technical specification to include an explicit association of the design task to a specific release of the cloud platform.

The evaluation of the IT artifacts (e.g. cloud platform or resulting multi-enterprise business processes) was conducted during the testing phase using an accept or fail criterion (e.g. did the service interaction and business process result in a successful connection and transmission of an information payload using specified canonicals, communications protocols, and invocation methods). A successful test required acceptance (signature) by the enterprise (Mohawk) and the collaborating business partner. If design revisions were necessary to address issues or gaps identified during testing, the additional design costs were itemized and reported by the cloud services broker. A successful artifact implementation is indicated by an evaluation and demonstration date on the project management template. All design tasks initiated during the study, were implemented during the study (i.e. there were no in-complete or partial designs). Table 4 below provides a summary of the data elements collected prior to and during the study using the pre-existing project planning template and technical specification documents.

Project Planning Template	Technical Specification Document
Project Identifier Project Manager Project Description Business Partner Planned Design Hours Actual Design Hours Planned Project Cost Actual Project Cost Project Start Date Project Test (Eval) Date Project Completion (Demo) Date Project Approval/Signature	Project Identifier Project Manager Business Partner Project Description Technical Specifications Service Interaction Type Originating Service ID Terminating Service ID Originating Service Owner Terminating Service Owner Originating Service Canonical Terminating Service Canonical Service Invocation Method Communications Method Transformation Mapping Service Linkages (Choreography) Cloud Platform Version

Table 4. Project Planning and Technical Specification Data Elements

The standardized project management documents (project planning template and technical specification) captured data necessary to answer the research question. This data informs the notion of business process agility, measured in quantitative dimension of time agility (design time) and in the qualitative dimension of range agility (i.e. capabilities). Enhanced business process agility is demonstrated by faster (and lower cost) design and deployment of a wider range of business integration capabilities, relative to those previously used in the case study environment and available in the existing solution space. The data collected also informs the relationship between the primary and secondary design phases.

A total of 101 project planning documents and technical specification (each) were leveraged in the study (6 functionality releases of the cloud platform during the study, 39 pre-study service interactions, and 56 service interaction designed and deployed during the two-year study). The 101 project planning templates and technical specification documents were reviewed and approved by the assigned project manager and this researcher. The purpose of the review was to validate the completeness and accuracy of the data collected. A number of inconsistencies in the two documents types were identified and corrected (e.g. missing dates, absence of a technical detail on service invocation methods). Data about the design time, design cost, and implementation date for each of the design tasks was compared for accuracy against the cloud service broker invoices. The quantitative and qualitative data collected using the 101 project planning and technical specifications documents required preparation (e.g. organization, codification, and transcription) to facilitate data analysis and presentation of results. The step-by-step process used to prepare (organize, codify, and transcribe) the data collected in the design-evaluation-demonstration phases is detailed in section 3.3.3.

3.3.2.4 Communication Phase

The Communication Phase requires that the design science researcher communicate the research problem and its importance, provides a concise representation of the IT artifact and its utility and novelty, and its effectiveness in addressing the organizational problem to both researchers and professional audiences. During the two-year study, there were numerous opportunities to communicate the research motivation, findings, and conclusions have been documented by date, venue or event, and the target audience. The communications events were recorded by this researcher and are a matter of public record. Communications will continue beyond the successful defense of this research, as this researcher intends to publish the research findings and results in scholarly journals. These communications events were recorded using the codebook depicted in table 5. In addition to the events and venues listed below, the research was communicated in several internet blogs on the topic of cloud based integration.

Dataset Column	Variable Description	Variable Name	Variable Type
A	Communications ID	COM_ID	Numeric
B	Communications Date	COM_DATE	Date
C	Communications Event	COM_EVENT	Text
D	Target Audience	AUDIENCE	Text

Table 5. Design Science Communications Codebook

3.3.3 Design-Demonstration-Evaluation Data Preparation

This section describes the procedures used to prepare the data collected in the primary and secondary design-demonstration-evaluation phase during the period of October 2010 through March 2012 and prior to the study during the period of April 2008 through September 2010. The data collected prior to the study represents designs using traditional on-premise business integration solutions, and provides a comparison design time and cost. The following sections (3.3.3.1 – 3.3.3.3) describe the procedures used during the period of April 2012 through June 2012 to organize, codify, and transcribe data for subsequent analysis and presentation.

3.3.3.1 Data Organization

As described, data about the design, demonstration, and evaluation activities in primary and secondary phases were captured using standard project management documents consisting of a technical specification document and a project planning template. A total of 101 technical specifications and project planning documents were created prior to and during the study (e.g. 39 business processes designs pre-study and 56 designs during the study, and 6 design releases of the cloud platform). The documents were organized in a central file repository using a file naming convention of TS*.doc for technical specifications documents and PP*.doc for project planning documents. The wildcard (*) in the file naming convention is the unique project identifier to establish a relationship between the project planning template and the technical specification for each of the 101 design activities.

3.3.3.2 Data Codification

At this point in the data preparation process, the project planning and technical specification documents established during the design-demonstration-evaluation phase had been collected and organized by design activity. The next step in the process was to apply coding techniques to further organize the data in the documents for transcription pertinent and subsequent data analysis. To accomplish this, data codebooks were established for three general categories: primary design activities (cloud platform), secondary design activities (service interactions), and the service registry representing the inventory of business services used to orchestrate multi-enterprise business processes. The data codebooks used to codify data from the project planning templates and technical specifications are presented in detail below.

Platform Codebook. During the study, design and development activities were executed to incrementally add capability and functionality to the cloud-based integration platform, which in turn enabled new types of secondary business process designs. The evolution of the cloud integration platform conducted in the design-demonstration-evaluation phase was captured in six (each) project planning and technical specifications documents. Data collected from the project planning documents included platform design identifier (i.e. P01), design start dates, the demonstration dates. A description of the platform functionality delivered was extracted (and summarized) from the technical specifications document. The codebook established for this data is depicted in table 6 below and is referred to as the Cloud Service Brokerage Platform Evolution Codebook as these capabilities were delivered incrementally by the cloud broker.

Variable Number	Variable Description	Variable Name	Variable Type	Variable Cell/Column
0	Column Labels			A(1)
1	Platform Unique ID	PLATFORM_ID	Text	B(1)
2	Design Start Date	DES_DATE	Date	C(1)
3	Demonstration Date	DEMO_DATE	Date	D(1)
4	Platform Functionality	FUNCTION	Text	E(1)

Table 6. Cloud Service Brokerage Platform Evolution Codebook

Service Codebook. Primary design activities pursued the cloud integration platform and a collection of technical and business services. In this study there were three different types of services (e.g. business, invocation, and interface) which vary in terms of their ownership (e.g. internally developed, from partners or cloud providers). Private and public business services are leveraged to orchestrate service interactions and multi-enterprise business processes in secondary design activities. Information about services available for use in the orchestration of business processes reside in a service repository. Data about the services was collected in the 101 technical specification documents. A total of 10 technical services and 56 business services were identified in the study and extracted from technical specification documents. A unique service identifier (e.g. S001) was established for the 66 technical and business services and the description the service using a verb-noun designation, (e.g. consume-order, publish-invoice, get-file) and the type of service (e.g. technical or business) were extracted from the technical specifications. The codebook for service repository is depicted below in table 7.

Dataset Column	Variable Name	Variable Description	Variable Type	Variable Response
A	SERVICE_ID	Unique Service ID	Text	S001, S002
B	SERVICE_DESC	Service Description	Text	Publish-Invoice
C	SERVICE_TYPE	Service Type	Numeric	1- Business 2 – Technical
D	SERVICE_DATE	Service Date	Date	10/10/2011
E	SERVICE_VER	Service Version Number	Numeric	1.0, 2.0

Table 7. Service Registry Codebook

The last codebook employed to organize and codify data collected in the project planning and technical specification documents was the service interaction codebook. The majority of the data collected during the design-demonstration-evaluation phase resulted from the secondary design of service interactions (the technical integration of two or more business services to exchange information). Service interactions become business processes when invoked in a particular sequence with a particular set of rules to achieve a business requirement. A service interaction (SI) consists of an originating business service (S_O) and a terminating business service (S_T). The originating and terminating business services are orchestrated (integrated) together using the capabilities of the cloud integration platform and value-added services of the cloud broker. An originating business service invokes the transport and transformation of a payload (e.g. order, invoice, data) through the cloud integration platform for consumption by a terminating business service. The originating and terminating business services consists of units of business capability (e.g. publish-order, consume-cash) and leverage technical services to initiate or invoke an action and expose the desired business functionality. The terminating business service may invoke another service or service interaction, enabling the orchestration and choreography of business processes. Figure 6 below represents the components and data elements associated with a service interaction.

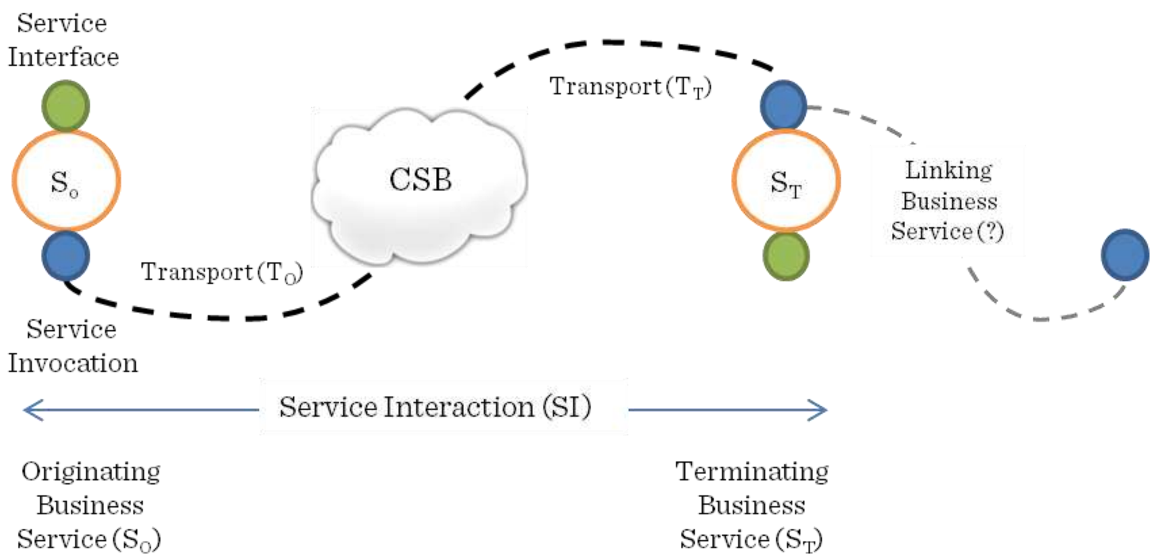

Figure 6. Components of a Business Service Interaction

The codebook developed to organize, codify and transcribe data about each service interaction is presented in below. The codebook was established to organize and transcribe information about the 95 service interactions designed in the study, to include data about the originating business service, terminating business service, and any cloud services brokerage functionality necessary to facilitate their orchestration. Although a single service interaction codebook was established, the codebook is presented in four sections (e.g. service interaction, originating business service, cloud service brokerage, and terminating business service) for readability purposes and to provide an explanation of the data and variables collected.

Service Interaction Codebook Section. In table 8 below, the service interaction section of the codebook is presented. A project management template and technical specification was established for each of the 95 service interactions used of designed as part of the study. Each service interaction was assigned a unique identifier (e.g. S001) and a description (e.g. consumes order from customer). The type of business pattern (SI_BUS_PAT) or functional role of the service interaction (e.g. supply chain, financials) were extracted from the technical specifications. Quantitative measures to include the design, demonstration, evaluation status were extracted from the project management template for the particular service interaction.

Dataset Column	Variable Name	Variable Description	Variable Type	Variable Responses/Codes
A	SI_ID	Service Interaction Unique ID	Text	SI001, SI002, ...SI00N
B	SI_DESC	Service Interaction Description	Text	Service to/from Partner/System
C	SI_BUS_PAT	Service Interaction Business Pattern	Numeric	1 - Supply Chain 2- Demand Chain 3 – Logistics 4 – Financials 5 – Other
D	SI_Design	Service Interaction Design Completed	Numeric	0 - No 1 – Yes
E	SI_DEMO	Service Interaction Demo Completed	Numeric	0 - No 1 – Yes
F	SI_EVAL	Service Interaction Evaluation Completed	Numeric	0 - No 1 – Yes
G	SI_DEMO_DATE	Service Interaction Demonstration Date	Date	MM:DD:YY

Table 8. Service Interaction Codebook (Service Interaction Section)

Originating Service Codebook Section. In originating business service section of the codebook is presented table 9 below. A service interaction consists of two services linked together via a cloud broker. The originating service is assigned a unique identifier (i.e. S001) and description (i.e. publish-order) from the service registry. The service can originate from Mohawk, a business partner, or a cloud provider. Business services can be invoked and their payloads can be transported and interfaced with internal systems in a number of ways. The notion of re-use of services is of importance to the study, thus originating business service orchestrated in the service interaction is coded as new or reused. The data transcribed using this codebook was extracted from the technical specification for the particular service interaction.

Dataset Column	Variable Name	Variable Description	Variable Type	Variable Responses/Codes
H	S_0_BUS_ID	Originating Business Service Unique ID	Text	From Service Registry (e.g.S001)
I	S_0_DESC	Originating Business Service Description	Text	From Service Registry (Publish-Order)
J	S_0_INT_ID	Originating Service Interface Unique ID	Text	From Service Registry (e.g.S001)
K	S_0_INV_TYPE	Originating Service Invocation Type	Text	0 – Unknown 1- On-Schedule 2 – On-Demand 3- Event-Driven
L	S_0_OWNER	Originating Business Service Owner	Numeric	1 – Mohawk 2 – Customer 3 - Mfg Partner 4 - Logistics Partner 5 – Financial Partner 6 - Cloud Provider
M	S_0_BUS_ID_DES	Originating Business Service Design	Numeric	0 -Unknown 1 - New 2 – Reuse

Table 9. Service Interaction Codebook (Originating Service Section)

Cloud Service Brokerage Codebook Section. The cloud brokerage section of the codebook is presented below in table 10. The cloud integration platform and cloud services broker enable interoperability between services to form multi-enterprise business processes. The cloud integration platform provides the software and infrastructure as a service to design, deploy and support the runtime execution of multi-enterprise business processes. The cloud services brokerage provides managed services in support of service interaction design, development, execution, monitoring, billing, and governance. The data transcribed using the codebook was collected in technical specifications documents for the service interaction with the exception of the design hours which was captured in the project management template.

The first entry in the cloud services brokerage section of the codebook records the version of the CSB platform (CSB_VERSION). This entry associates the service interaction and its originating and terminating business services to a version of the platform and functionality. This data seeks to inform the relationship between primary and secondary design activities, specifically how incremental platform functionality enables new types of designs for service interactions. The next two entries in the codebook (S_0_CONONICAL and S_T_CONONICAL) capture the type of canonical used in the originating and terminating business services. The cloud service broker provides translation services to map disparate canonicals (messaging standards) to enable business process interoperability. A wide range of canonicals are used in this study to include electronic data exchange (EDI), papiNet (used in paper industry), OAGIS (open applications group integration standard), BAI (bank administration institute), common web-standards (e.g. xml, xCBL), Cloud APIs, and a standard canonical for file transfer. The next two sections of the codebook record the type of messaging and transformation services provided by the cloud broker to enable interoperability of business services. The messaging delivery type (CSB_MSG_TYPE) can be asynchronous (one-way) or synchronous (request-reply). The transformation services (CSB_TRANSFORM) provided by the cloud broker may be pass-through or may include transformation services to enable interoperability between disparate systems. The final entry in the codebook records the total design time expended by the cloud broker to implement the service interaction (CSB_DES_TIME). The design time includes the effort for the service interface, service invocation and transformation services.

Dataset Column	Variable Name	Variable Description	Variable Type	Variable Responses/Codes
N	CSB_VERSION	CSB Platform Version	Text	P00, P01, ...PN (Platform)
O	S_0_CONONICAL	Originating Service Canonical	Numeric	1- EDI 2- papiNet 3- OAGIS 4- BAI 5- XML 6 – xCBL 7- Cloud API 8 – File
P	S_T_CONONICAL	Terminating Service Canonical	Numeric	1- EDI 2- papiNet 3- OAGIS 4- BAI 5- XML 6 – xCBL 7- Cloud API 8 – File
Q	S_0_TRANSPORT	Originating Service Transport Type	Numeric	1–FTP/s 2- HTTP/s 3–AS2
R	S_T_TRANSPORT	Terminating Service Transport Type	Numeric	1–FTP/s 2- HTTP/s 3–AS2
S	CSB_MSG_TYPE	CSB Messaging Type	Numeric	1 - Asynchronous (OneWay) 2 - Asynchronous (Reply) 3 - Synchronous (Reply)
T	CSB_TRANSFORM	CSB Transformation Services	Numeric	1 - Pass-through 2 – Transformation
U	CSB_DES_TIME	CSB Design Effort	Numeric	Hours

Table 10. Service Interaction Codebook (Cloud Service Brokerage Section)

Terminating Service Codebook Section. The terminating business service section of the codebook is presented in table 11. The codebook for the terminating service is identical to the originating service described above, with one exception. An additional variable is associated with the terminating service is linkage (S_T_LINKAGE). At the termination of the service interaction, there may be a linkage or invocation of another business service, referred as business process orchestration. As with the originating business service, all data transcribed using this codebook was collected from the project management and technical specification.

Dataset Column	Variable Name	Variable Description	Variable Type	Variable Responses/Codes
V	S_T_BUS_ID	Terminating Business Service	Text	From Service Registry
W	S_T_DESC	Terminating Business Service Desc	Text	From Service Registry
X	S_T_INT_ID	Terminating Service Interface ID	Text	From Service Registry
Y	S_T_INV_TYPE	Terminating Service Invocation Type	Text	0 – Unknown 1 – On-Schedule 2 – On-Demand 3 – Event-Driven
Z	S_T_OWNER	Terminating Business Service Owner	Numeric	0 – Mohawk 1 – Customer 2 - Mfg Partner 3 - Logistics Partner 4 – Financial Partner 5 - Cloud Provider
AA	S_T_BUS_ID_DES	Terminating Business Service Design	Numeric	0 –Unknown 1 – New 2 - Reuse
AB	S_T_LINKAGE	Terminating Service Linked to Service	Text	S_ID

Table 11. Service Interaction Codebook (Terminating Service Section)

3.3.3.3 Data Transcription

Using the platform, service, and service interaction codebooks described in the preceding sections, pertinent data was extracted from the appropriate documents and transcribed into Excel spreadsheets (platform.doc. service.doc, and service_interaction.doc, respectively). The data transcription process was conducted over a four week period in mid-May 2012 through mid-June 2012. A total of 6 functional releases were entered in the platform datasheet, 35 services were entered in the service repository, and 95 unique service interaction designs were entered into the service interaction datasheet. The dataset of service interactions designed or used in this study is presented in the Appendix of this thesis. There were no anomalies or gaps in the identification and transcription of quantitative data such as dates and design hours. The datasets (platform, service, service interaction) were independently reviewed for accuracy and completeness by two individuals knowledgeable of the design activities. This review resulted in the removal of a duplicate entry in the service registry and changes in the technical classification of several business services and service interactions.

3.4 Data Analysis Strategy

The data collection, organization, codification, and transcription procedures prescribed in this chapter served to position this design science researcher to perform data analysis to answer the research question. The intent of design science research in information systems is to design a novel IT artifact, to demonstrate its efficacy to address a business problem, and to make meaningful contributions to the academic and professional knowledge base of design.

As described, the goal of this research is to address a gap in the practitioner solution space by designing a novel way to effectively design and deploy multi-enterprise business process across a range of integration scenarios. In particular, the research question explores how a cloud-based architecture enhances business process agility in a medium-sized manufacturing enterprise. Therefore, the data analysis strategy employed to answer this research question focuses on demonstrating the efficacy of the cloud-based integration platform to enhance business process agility in this case study setting. In addition, the analysis of measurements and observations obtained in the study seeks to contribute to the scholarly and professional knowledge base to inform design (as a process) using the cloud as a business technology platform and supporting cloud services brokerage model to enable a wide-range of ongoing secondary designs to integrate business partners into a value network.

To demonstrate the efficacy of the designed IT artifact the notion of business process agility was operationalized into the components of range agility (capabilities available to conduct business process designs) and time agility (time to deploy these capabilities). Data collected during the primary design and secondary design activities provides evidence about the range of technical integration capabilities employed to address business integration requirements. This data and results can be compared with business integration capabilities available in the practitioner solutions space, thereby demonstrating the novelty of the IT artifact and the extent to which the solution addresses gaps in the practice domain and scholarly literature. The data collected on the design time and speed of deployment of multi-enterprise business processes can be compared to prior business integration methods and approaches used in the case study setting. Additionally, the data and results seek to demonstrate a decrease in design time and increase in the speed of deployment of business processes by leveraging the reuse of business services. In summary, the analysis of data collected from the secondary design activities seeks to demonstrate enhanced business process agility resulting from increased business integration capabilities and overall lower design time and faster time to deployment in this case study environment.

The data collected during the research study also seeks to inform the higher order concept of the service-oriented enterprise. The research agenda explores how the converged benefits of service-oriented architecture and cloud computing enable an organizational focus on the flexible design of business services, processes, and networks. As this research represents one of the first known instantiations of a cloud-based integration platform to integrate both traditional business partners and emerging cloud service providers, the data collected from the study seeks to contribute to the knowledge base of design. The research study seeks to provide an understanding of a service-oriented approach to multi-enterprise business process design, to inform the relationship between primary design (cloud platform) and secondary design (business processes) activities, and to suggest the growing importance of secondary designs to deliver business value. The data collected in this study has been organized, codified, and transcribed to evaluate the adherence to the service-oriented design principles, to associate primary and secondary design activities, and to inform secondary design outcomes in terms of their business value and contribution.

3.5 Limitations, Reliability, and Validity

All research has limitations which are usually associated with the research methods employed (Leedy & Ormrod, 2010), as the reliability, validity, and generalizability of the research results and conclusions are directly related to how those results were obtained. Case study research has been criticized for lack of rigor in the collection, construction, and analysis of the evidence introduced by the subjectivity or bias of the researcher and others involved in the case study (Yin, 1984; Hamel, 1993). Design science research has been similarly criticized for the lack of methodological rigor and well established guidelines for the conduct and evaluation of high quality research (Hevner et al., 2004, Järvinen, 2007). This research study also has limitations associated with the collection, reduction, and analysis of qualitative data using case study and design science research methods (Miles and Huberman, 1994) and potential issues with bias introduced by an insider researcher (Unluer, 2012). To help readers of the study to evaluate the reliability (e.g. accuracy of measurements) and validity (e.g. generalizability of findings) of the results and findings, the researcher must identify any limitations (Mertler & Vannatta, 2009), describe the evaluation procedures and implementation context (Miles and Huberman, 1994), and provide their own perspectives to contextualize any claims made to take account of any possible influence or bias (Unluer, 2012).

The Introduction and Literature Review Chapters of this thesis provide the background and context in which the research question is situated and the motivation for the pursuit of the design of a novel IT artifact to address a business problem. These Chapters provide readers of this research with context to evaluate applicability and transferability of the results, findings, and recommendations in their unique situations and settings. Literature support was used extensively to position the study in the context of the exiting body of knowledge, to establish the presence, importance, and nature of the problem motivating the research, and to select the appropriate methods to answer the research question (Levy & Ellis, 2006). This research is situated in the context of a medium-sized manufacturing enterprise responding to disruptive external market forces with a business model that leverages the complementary capabilities of a network of partners to deliver value-added products and services. While the issue of firm-to-firm interoperability and business strategy transformation may have broader applicability, the uniqueness of this study is in why and how an innovative IT artifact was conceived, designed, and implemented to address this business problem in a more effective way.

To answer the research question, a design science research in information systems process model developed by Peffers et al. (2007) was selected as the methodological framework for this research study. As described, the design science research in information systems process model developed by Peffers et al. (2007) represents the synthesis of prior influential design science research and seeks to provide a "mental" model for others to evaluate the quality and applicability of design science research in information systems. The design science research in information systems process model requires the establishment of a conceptual framework, followed by the design of the system architecture, and concluding with the demonstration of the IT artifact for testing and evaluation (Hasan, 2003; Nunamaker et al., 1991). Arguably, a strength of this study is in the establishment of the conceptual framework which extensively leveraged the literature and the input from a doctoral committee represented by experts in the field of enterprise architecture (Bernard, 2005), service-oriented architecture (Marks & Bell, 2006), and cloud computing (Marks & Lozano, 2010). A potential limitation of the study may be related to the rigor in the methods employed to identify solution alternatives and rationale for why these solutions did not effectively address the research problem. Only a cursory review of the solutions landscape was conducted by this researcher and potentially bias research from an advisory firm was used to establish a representative set of solution vendors. This limitation introduces the potential for bias in the identification of available solutions and the possible existence of alternative solutions in practice, thereby invalidating the novelty of the IT artifact pursued in this study. This limitation was mitigated to some degree as the conceptual design framework developed in this study explicitly addressed gaps in the scholarly literature and in practice. Moreover, the uniqueness and novelty of the primary IT artifact resulting from this study, the cloud integration platform, has been corroborated during the two-year the study by several IT advisory firms and professional recognitions.

A limitation of design science research in information systems is the issue of perishability, "as rapid advances in information technology can invalidate design research results before they are implemented" (Hevner et al., 2004). Several integration Platform-as-a-Service (iPaaS) vendors have entered the market during the course of this study, however, their solutions have not fully embraced service-oriented architecture principles and cloud computing deployment characteristics in their solutions. Moreover, as described in the final chapter of this thesis, the primary contribution of this study is not the instantiation of a cloud integration platform, but rather how these emerging cloud platforms enable a new approach to service-oriented design in the enterprise that focuses on business goals and objectives, not the underlying technology.

To help readers evaluate the reliability of results, findings, and recommendations from this study, consideration was applied to describe what data was collected, how it was collected, and why it was collected during the design-development-evaluation phase. As described, the data collected prior to and during the study used pre-established project planning procedures and instruments (e.g. project planning template and technical specification document). The use of pre-existing instruments and procedures helped to reduce error in the data collection process and also to simplify the preparation of data for subsequent analysis. The data collected in these instruments consisted of primarily quantitative data (e.g. design time and cost, dates) which was reviewed for completeness and accuracy by two other members of the project team. The organization, codification, and transcription of this data were prescribed by data codebooks to ensure their reliability for subsequent analysis.

The testing and evaluation of the 6 cloud platform functionality releases and the 95 service interactions designed and implemented prior to and during the study did not employ rigorous methods. Rigorous evaluation methods are known to be difficult to apply in design science research (Tichy 1998; Zelkowitz and Wallace 1998) and the methods used vary depending on the type of artifact developed and the nature of the design requirement the artifact intended to address (Levy & Ellis, 2006). As prescribed in the conceptual framework and guiding design principles, service interactions represent the orchestration of two or more business services and their technical integration is executed through the cloud platform and by the cloud broker. Thus, the testing and evaluation criteria consisted of adherence to these principles, namely the demonstration of successful information exchange through the cloud platform between two business services inside or outside the enterprise. The data collection and evaluation methods employed in this study are believed to be sufficient to address the research question. As the research question explored the notion of business process agility operationalized in terms of the range of capabilities and time-to-deployment. Where time agility is measured in terms of hours, cost, and dates and range agility is informed by business integration use cases (e.g. A2A, B2B, C2P, and C2C) demonstrate and the technical integration capabilities (e.g. messaging, interface, canonical, transport, and transformation) employed.

To further enable readers of this study to evaluate the trustworthiness and plausibility of the results and recommendations, the role, influence and potential bias of the insider researcher must be clearly articulated. This practitioner researcher pursued the simultaneous objectives of addressing a business challenge while also seeking to make meaningful contributions to the scholarly literature and practice domain of information systems design. This duality of roles did not directly influence the reliability of data collection techniques described in this chapter, as the data captured by project managers employed pre-existing data collection methods and instruments.

However, the concurrent pursuit of business requirements and a research agenda did have the effect of increasing the number and types of business integration scenarios designed and deployed during the study. Meaning some of the integration use cases were pursued to address explicit business requirements while others were pursued to demonstrate a unique or new integration use case scenarios not deployed in practice. Rather than creating tension between business demands and scholarly pursuits, the duality of roles enabled the synergistic pursuit of a range of business integration use cases; some motivated by known business requirements and others the result of discovery and experimentation. Insider access to a case study setting willing and able to pursue concurrent business requirements and experimentation of new techniques represents a particular uniqueness in the conduct of this study, but also presents a challenge for others to fully replicate the methods employed and research results.

The purpose of the methods used in this study was to answer a research question focusing on the dimensions of a range of capabilities and the time to design and deploy multi-enterprise business processes. These methods focused on the collection of data (e.g. range of capabilities and time to deploy) for each secondary design, defined as a service interaction in this study. As described, a service interaction consists of the technical integration of two business services intermediated through a cloud platform and by a cloud broker. A service interaction becomes a business process when described in the context of a how it achieves a particular business objective. In the final chapter, the results from the study are presented in terms of business objectives and benefits. To be clear, minimal data was collected and presented in this study to substantiate the benefits resulting from the design and implementation of the cloud integration platform and multi-enterprise business process designs. The perspectives offered on business impacts are intimately related to the unique context and circumstances in the case study environment and are highly subjective representations from this researcher.

In the final chapter of this thesis, further reflection and perspective is provided on the quality of the research methods employed in this study, the strengths and weaknesses of the design science research methodology, and the limitations of the generalizability and applicability of the results, findings and recommendations.

CHAPTER 4
RESEARCH RESULTS AND FINDINGS

4.0 Chapter Overview

The objective of the chapter is to present the research study's data and findings with only minimal interpretation. As prescribed by the design science research in information system process, the data seeks to demonstrate the novelty and efficacy of the designed IT artifact to solve a known business problem. In this study, the data informs the question how does a cloud-based service-oriented infrastructure and cloud services brokerage model enhance business process agility in a medium-sized manufacturing enterprise? In the larger context, the case study seeks to provide insight into the transition of a product-based firm towards a service-oriented enterprise to enable the effective integration of business processes with a network of business partners to offer value propositions to its customers. As prescribed by design science research, the data and results seek to make a meaningful contribution to the scholarly and professional knowledge base of design through an exploration of how a cloud-based architecture provides a platform to enable the efficient and flexible design of business services, processes and networks.

The chapter's organization aligns with the nominal sequence of the six phases of the design science research in information systems process – from the research motivation, to solution objectives, through the design and evaluation cycles, and to the communication of results. The context and motivation for the conduct of this research study was presented in the

Introduction Chapter. The intended contributions to the knowledge base of design resulting from the research study were presented in the Literature Review Chapter. Design science research requires an explanation of the novelty of the designed IT artifact as a solution that addresses a known business problem in an innovative or more effective way.

Thus, this chapter begins with the presentation of the results from the evaluation of existing business integration solutions and an assessment of their capability to address the research problem and the requirements in the case study setting (section 4.1). The following section presents the objectives of the desired solution to address the business problem in an innovative or more effective manner (section 4.2). The solution objectives are presented as the guiding principles for the design of an artifact based on the converged benefits of service-oriented architecture and cloud computing. The following two sections present the results from activities associated with the design, demonstration and evaluation during the primary and secondary design phases. The primary activities pursued the design, development, and implementation of a cloud integration platform and the establishment of a repository of technical and business services (section 4.3). The secondary design activities pursued the design, demonstration and evaluation of service interactions leading to the design of multi-enterprise business (section 4.4). The results emerging from the secondary design activities are presented in a technical context (4.4.1) and business context (4.4.2). The next section presents the communications activities conducted during the study period (section 4.5). In section (4.6), the Chapter concludes with a summary of the study's results and findings as a transition to the presentation of the research study's overall conclusions, interpretations, discussion, and recommendations in Chapter 5.

4.1 Review of the Business Integration Solution Space

A requirement of the Identify Problem and Motivation Phase in the design science research process is to conduct a review of the solutions landscape to identify possible alternative solutions and to validate the novelty of the proposed technology-based artifact. During the period of April 2010 through June 2010 a high-level review of existing business integration vendor solutions was conducted to assess their capability to address the business problem in the case study environment. Six technology vendors representing mature enterprise-class solutions, emerging cloud-based solutions, and mid-market solutions were evaluated. The vendor solutions were evaluated based on three categories; the total purchase cost, solution complexity, and technical capabilities. The business integration solutions evaluated were from Dell Boomi.com and IBM CastIron (from the emerging cloud solution space), Tibco and Software AG WebMethods (from the enterprise-class solutions space), and Extol and Infor (from the mid-market solutions space and deployed in the case study environment).

The results from the three month evaluation are presented below in table 12. The six vendor solutions were evaluated across three major categories: purchase price, solution complexity, and technical capabilities. Technical capabilities were evaluated based on the solutions functionality and effectiveness to address application-to-application (A2A), business-to-business (B2B), cloud-to-on-premise (C2P), and cloud-to-cloud (C2C) business integration scenarios. A rating scale of 1 to 5 (1-Poor, 2-Fair, 3-Average, 4-Good, and 5-Excellent) was employed. A rating score of zero (0) indicated the solution did not provide the required capability. The technical capabilities rating score is the average of each of the four business integration use case (A2A, B2B, C2P, and C2C) ratings. The overall rating is represented by the weighted average of the purchase price (30%), solution complexity (30%), and technical capabilities (40%).

			Technical Capabilities (40%)					
	Purchase Cost (30%)	Solution Complexity (30%)	A2A	B2B	C2P	C2C	AVG	Overall Score
Boomi.com	3	4	1	2	2	2	1.8	2.8
CastIron	3	3	1	3	2	2	2.0	2.6
Tibco	1	1	4	4	2	2	3.0	1.8
WebMethods	1	1	4	4	2	2	3.0	1.8
Extol	3	3	3	3	0	0	1.5	2.4
Infor	2	2	2	2	0	0	1.0	1.6
TOTAL	2.2	2.3	2.5	3.0	1.3	1.3	2.0	2.2

Table 12. Results of Business Integration Vendor Solutions Space

The highest overall assessment score was attributed to Dell Boomi.com at 2.8, followed by IBM CastIron at 2.6. These two vendor solutions represented the leaders in the emerging cloud-based integration space. Note at the time of the evaluation Boomi.com and CastIron were privately held start-up firms who were later acquired by Dell (November 2010) and IBM (May 2010) respectively.

In the mid-market solutions space, two vendors were evaluated, Extol and Infor. These are on-premise business integration solutions both of which have been deployed in the Mohawk environment. These mid-market business integration solutions did not leverage service-oriented architecture and did not fully address the requirements of cloud-based integration, thus a rating score of 0 (zero) and therefore disqualification as potential solutions.

In the enterprise-class business integration solutions space, Tibco and Software AG held a leadership position at the time of this evaluation. These two solutions primarily focused on on-premise or application-to-application (A2A) and business-to-business (B2B) integration use case scenarios and thus each received a rating score of 4 (Good). However, at the time of the evaluation, Tibco and Software AG were pursuing cloud-based integration and software-as-a-service (SaaS) deployment models, but these capabilities were not fully developed, thus the rating score of 2 (Fair). The Tibco and Software AG solutions were relatively complex to manage and their cost (in excess of $1M) was considered to be prohibitive for a medium-sized enterprise. Thus, Tibco and Software AG were given rating scores of 1 (Poor) for both purchase cost and solution complexity.

In summary, the overall assessment score of the six vendor solutions was 2.2, in the lower range of Average to Fair. The highest overall scores were attributed to the emerging cloud-based solutions Boomi.com and CastIron with rating scores of 2.8 and 2.6 respectively. At the time of the evaluation, Boomi.com and CastIron had minimal capabilities to support on-premise application-to-application functionality, thus a rating score of 1 for each. The mid-market solutions from Extol and Infor were disqualified because of the lack of capability to integrate internal systems and processes with cloud-based services. The enterprise-class solutions from Tibco and Software AG received low overall scores (both 1.8) because of the relatively high cost of ownership and the technical complexity of their solutions.

4.2 Summary of Solution Design Principles

The Define Solution Objectives Phase of the design science research in information systems process requires definition as to how and why the desired IT artifact is more efficient and effective at addressing the problem space than current solutions. The thesis of this study posits that the convergence of service-oriented architecture and cloud computing offers the potential for a new platform to enable more efficient and effective integration of traditional business partners and emerging cloud providers.

In working sessions conducted during the period of July 2010 through September 2010 the philosophy and principles that would guide the design of a cloud-based integration platform were established. The results from these working sessions were captured in two documents entitled: Service-Oriented Architecture Manifesto and Cloud Computing Reference Model. The content of these two documents emphasized the service-oriented paradigm as an aligned technology and business strategy to achieve enhanced levels of business process agility by leveraging a cloud-based service-oriented infrastructure and cloud services brokerage model. The salient points from these documents were extracted and summarized as the guiding philosophy and principles for the design of a cloud integration platform. The incremental design and deployment of the cloud integration platform and subsequent secondary designs were directly influenced by these guiding principles as each release of functionality was evaluated for adherence to these guidelines. The ten (10) guiding design principles (GP1 - GP10) embodied in the working documents are summarized and presented below in table 13.

Guiding Design Philosophy and Principles	
GP1	The design shall pursue the realization of a service-oriented enterprise - a business strategy to integrate internal business processes with those of external partners to offer customers new and compelling value propositions.
GP2	The design shall leverage a service-oriented paradigm as an approach for realizing the strategic objective of enterprise agility - the organizational capability to efficiently and effectively respond to business change.
GP3	The design shall deliver capabilities to enhance business process agility - to establish interoperability between internal and external applications, processes, services, and data in a flexible, cost-effective, and evolutionary manner.
GP4	The design shall consider current and future state requirements for multi-enterprise business process orchestration - the design shall deliver any-to-any interoperability, location transparency, and technology independence.
GP5	The design shall employ service-oriented architecture as a business-driven approach to apply the paradigm of service orientation - the service-oriented architecture shall be vendor-neutral and technology neutral.
GP6	The design shall employ the use of services consisting of discrete units of business logic to compose and orchestrate multi-enterprise business processes - services shall be granular, reusable, interoperable and independent of technology.
GP7	The design of services and their orchestration in business processes shall be business-driven; the technical details of service interfaces and invocation shall be abstracted from the business in the domain of the cloud services broker.
GP9	The design shall result in a cloud-based service-oriented infrastructure that defines the IT infrastructure in terms of services - the service-oriented infrastructure shall be discoverable, scalable, measurable, secure, and exposed using standard interfaces.
GP9	The design of the service-oriented infrastructure shall be utility-based, scalable on-demand, and supportive of the essential cloud characteristics and deployment models to include software, infrastructure, and platform as-a-service.
GP10	The design shall employ a cloud services brokerage model to provide value-added services to integrate on-premise and cloud applications, processes, services, and data – services include connectivity, transformation, aggregation, monitoring, and billing.

Table 13. Guiding Design Philosophy and Principles

4.3 Primary Design Results and Findings

In this study, primary design and development activities pursued a cloud-based service-oriented infrastructure (the cloud integration platform) and reusable technical and business services. The cloud integration platform and repository of services provided the foundation for multiple secondary design activities conducted by the enterprise. The results of the primary design activities during the two-year study are presented in the following sections.

4.3.1 Primary Design Phase - Cloud Integration Platform

During the period from October 2010 through April 2012 the cloud integration platform was designed and developed in seven phases (P00 – P07). The desired capabilities of the cloud integration platform were developed in accordance to the ten guiding design principles and in response to business requirements and feedback from secondary design activities. The cloud integration platform, also referred to as an integration Platform-as-a-Service (iPaaS), was designed, implemented, and evaluated in an incremental and evolutionary manner as described in the following section.

The initial phase (P00) represents the baseline state of the platform at the start of the study which provided traditional EDI messaging. Phases P01 and P02 established the cloud-based service-oriented infrastructure and secure network connectivity to Mohawk's private cloud. The private cloud was designed as lightweight employing virtualized computing resources and open source software (Linux and JBOSS) to access internal and cloud business services. The following three phases (P03-P06) delivered capabilities to enable the design of multi-enterprise business processes that leveraged technical services to enable integration with data files, databases, and web-services independent of their technology and location. The final phase (P07) of the cloud integration platform delivered capabilities to perform more complex business process orchestration and choreography. A summary of the cloud-based integration platform design phases and associated capabilities is presented in table 14.

	Date	CSB Platform Description of Additional Functionality
P00	Pre Study	Data Exchange Platform. The platform prior to the start of the study. The platform delivered functionality for EDI Messaging for multiple protocols types. Primarily supported business-to-business (B2B) use cases only.
P01	Dec 10	Cloud Service-Oriented Infrastructure. Establishment of an IT architecture that leverages business services and provides a platform-as-a-service with the essential characteristic of cloud computing deployment models.
P02	Dec 10	Cloud-to-On-Premise Connectivity. Establish network connectivity between the Cloud-Based Service-Oriented Infrastructure and Mohawk's Private Cloud through a secure VPN connection. Connectivity enables integration of internal and external services to form multi-enterprise business processes.
P03	Jan 11	Web Service Bus (Datafile Get/Put). Development of a web service bus to enable business process integration with cloud or on-premise file systems (enterprise service bus) to pick-up (get) or drop-off (put) files/messages.
P04	Feb 11	Web Service Bus (Database Insert/Select). Development of a web service bus (or service router) that enables business process integration with cloud or on-premise databases to retrieve (select) data or insert data to/from databases.
P05	Mar 11	Web Service Bus (Service Publish/Consume). Development of a web service bus to enable business process integration with cloud or on-premise services (or web services) to publish or consume public or private web services.
P06	Apr 11	Web Service Bus (Service Publish/Consume). Development of a web service bus (or service router) that enables business process integration with cloud application programming interfaces (APIs).
P07	Feb 12	Cloud-Based Business Process Orchestration. Enhancements to the service router to enable business process choreography, orchestration and workflow functions such as carbon copy, branching, splitting, aggregation etc.

Table 14. Cloud-Based Business Integration Platform Evolution

4.3.2 Primary Design Phase – Technical and Business Services

Development of both technical and business services were conducted as part of the study's primary design activity. Business services provide granular units of business functionality that are used by enterprise users to design and deploy a multi-enterprise business process (i.e. secondary designs). Two or more business services are integrated together to form a service interaction, when applied in a business context with an external partner becomes a multi-enterprise business process. Business services are discoverable in a service registry accessible in the cloud platform and they can be developed and owned by the enterprise or made available by external business partners or cloud service providers. In this study, the convention to describe a business service is a verb (action) and noun (document, message, data types) combination. Examples of business services designed and used in the study are publish-order, consume-invoice, and consume-freight rate.

During the two-year research study a total of 46 distinct business services were leveraged in secondary design activities to choreograph multi-enterprise business processes. A total of 16 of these business services were designed prior to the start of the study (pre-existed), 32 were designed by the enterprise during the study, and 12 business services were discovered and accessed from cloud service providers. Table 15 below presents the repository of business services utilized during this study to include the type of service, service date, and service version. A description of technical services designed and developed in the study is provided in the later part of this section.

Service ID	Service Description	Type	Date	Version
S001	Publish-Customer Order	Business	04/01/08	1.0
S002	Consume-Customer Order	Business	04/01/08	1.0
S003	Publish-Order Acknowledgment	Business	04/17/08	1.0
S004	Consume-Order Acknowledgment	Business	04/17/08	1.0
S005	Publish-Shipping Notification	Business	04/25/08	1.0
S006	Consume-Shipping Notification	Business	04/25/08	1.0
S007	Publish-Warehouse Order	Business	08/15/08	1.0
S008	Consume-Warehouse Order	Business	08/15/08	1.0
S009	Publish-Warehouse Transfer	Business	08/20/08	1.0
S010	Consume-Warehouse Transfer	Business	08/20/08	1.0
S011	Publish-Warehouse Receipt	Business	08/30/08	1.0
S012	Consume-Warehouse Receipt	Business	08/30/08	1.0
S013	Consume-Invoice	Business	02/01/10	1.0
S014	Publish-eCatalog	Business	04/01/10	1.0
S015	Consume-eCatalog	Business	04/01/10	1.0
S016	Publish-Invoice	Business	04/15/10	1.0
S017	Publish Purchase Order	Business	12/01/10	1.0
S020	Publish-Freight Rate	Business	01/01/11	1.0
S021	Consume-Freight Rate	Business	01/01/11	1.0
S022	Publish-Cash Statements	Business	01/10/11	1.0
S023	Consume-Cash Statements	Business	01/10/11	1.0
S024	Publish-Account Analysis	Business	01/15/11	1.0
S025	Consume-Account Analysis	Business	01/15/11	1.0
S028	Publish-Inventory	Business	02/01/11	1.0
S029	Consume-Inventory	Business	02/01/11	1.0
S030	Publish-Remit Advice	Business	02/15/11	1.0
S031	Consume-Remit Advice	Business	02/15/11	1.0
S034	Publish Vendors	Business	03/15/11	1.0
S035	Consume Vendors	Business	03/15/11	1.0
S040	Consume-Credit Check	Business	06/01/11	1.0
S042	Consume-Employee File	Business	07/01/11	1.0
S043	Publish-Currency	Business	07/15/11	1.0
S044	Consume-Currency	Business	07/15/11	1.0
S045	Publish-Credit Check	Business	09/15/11	1.0
S047	Consume-eRebates	Business	10/25/11	1.0
S048	Consume Purchase Order	Business	02/01/12	1.0
S049	Publish-Quote	Business	02/20/12	1.0
S050	Consume-Quote	Business	03/30/12	1.0
S051	Publish-Customer	Business	03/30/12	1.0
S052	Consume-Customer	Business	03/30/12	1.0
S053	Publish-Shipments	Business	03/30/12	1.0
S054	Consume-Shipments	Business	03/30/12	1.0
S055	Publish-Credit	Business	03/30/12	1.0
S056	Consume-Credit	Business	03/30/12	1.0

Table 15. Service Registry of Business Services

In this study, the business services used to design multi-enterprise business processes are different from technical services. Business services and their resulting business processes depend upon technical services to initiate the business process (service invocation) and to interface with the underlying technical infrastructure (service interface). The design and governance of these technical services is in the domain of cloud services broker. As a result, and by purposeful design, much of the technical complexity of establishing interoperability between diverse business services is abstracted from the enterprise. Thus, enterprise users (Mohawk) primarily focus on the design of business processes that leverage the repository of internal and external business services. Presented below in table 16 are the ten technical services designed and utilized in this study. These technical services were developed as part of cloud platform design phases P03 – P06. The purpose of these technical services is to enable seamless and end-to-end integration with internal systems, applications, processes, services, and data through direct interaction with file systems, databases, services, cloud APIs, and web-pages.

Service ID	Service Description	Service Type	Service Date	Service Version	Platform Version
S018	Put-Data File	Technical	01/01/11	1.0	P03
S019	Get-Data File	Technical	01/01/11	1.0	P03
S026	Select-Database	Technical	02/01/11	1.0	P04
S027	Insert-Database	Technical	02/01/11	1.0	P04
S032	Consume-Web Service	Technical	03/01/11	1.0	P05
S033	Publish-Web Service	Technical	03/01/11	1.0	P05
S036	Publish-Web Form	Technical	04/01/11	1.0	P05
S037	Consume-Web Form	Technical	04/01/11	1.0	P05
S038	Publish-Cloud API	Technical	05/01/11	1.0	P06
S039	Consume-Cloud API	Technical	05/01/11	1.0	P06

Table 16. Service Registry of Technical Services

4.4 Secondary Design Results and Findings

The primary motivation for this study was to demonstrate a novel approach for the design of multi-enterprise business processes to integrate the firm's internal capabilities with those of a network of business partners. Thus, the preponderance of design activity in this study pursued secondary designs that leveraged the capabilities of the cloud integration platform. In this research study, secondary design activities pursued the design, demonstration and evaluation of service interactions where two business services are technically integrated together to exchange information. When business services are orchestrated to achieve a business goal with external partners and/or service providers, they become multi-enterprise business processes. The following two sections present the results of the secondary design activities pursued during the period of October 2010 through March 2012. The results inform the research question through a demonstration of enhanced business process agility using a cloud integration platform in the case study environment. Business process agility is operationalized in terms of an increased range of integration capabilities relative to existing solutions and the speed of design and deployment as compared to prior techniques used in the case study environment. The presentation of the results of secondary design activities begins with a technical context to include descriptive statistics and a series of tables illustrating increased functionality and decreased time to deployment for multi-enterprise business processes leveraging the cloud integration platform. The next section provides a business context for the secondary designs to inform the notion of a service-oriented enterprise by demonstrating partner integration and the formation of service systems and networks as a means to offer customers with new and compelling value propositions.

4.4.1 Secondary Designs – Technical Context

In this section, the results and findings from the secondary design activities are presented in a technical context. The results are presented in a series of tables that illustrate the range of service interaction use cases, design time reductions based on the reuse of business services, and technical capabilities such as service interfaces, invocation methods, messaging types, canonical types, and transformation services.

The results were transcribed into a secondary design datasheet during the period of April through June 2012. The data collected includes a 39 pre-study (legacy) service interactions designed and deployed during April 2008 through September 2010 using traditional on-premise business integration methods and techniques. This data is used as a comparative to service interactions designed and deployed during the study period using the cloud-based integration platform. It should be noted that the 39 pre-study service interactions were migrated to the cloud integration platform for improved network connectivity, security, and governance. A total of 56 service interactions were designed and deployed during the period of October 2010 through March 2012 using the cloud integration platform. The complete secondary design datasheet (with pre-study and study results) is provided in the Appendix. Figure 7 depicts as sample datasheet containing the 39 legacy service interactions (SI01 – SI40) which are listed in a (BLACK) font. Figure 8 depicts the 56 service interactions (S041 – S095) design and developed during the study which is distinguished in (RED) font.

Service Interaction							Originating Service (S_O)						CSB								Terminating Service (S_T)						
SI_ID	SI_DESC	SI_BUS_PAT	SI_DESIGN	SI_DEMO	SI_EVAL	SI_DEMO_DATE	S_O_BUS_ID	S_O_DESC	S_O_INT_ID	S_O_INV_TYPE	S_O_OWNER	S_O_BUS_ID_DES	CSB_VERSION	S_O_CONONICAL	S_T_CONONICAL	S_O_TRANSPORT	S_T_TRANSPORT	CSB_MSG_TYPE	CSB_TRANSFORM	CSB_DES_TIME	S_T_BUS_ID	S_T_DESC	S_T_INT_ID	S_T_INV_TYPE	S_T_OWNER	S_T_BUS_ID_DES	S_T_LINKAGE
SI001	Consume Customer Order from Customer A	2	1	1	1	04/01/08	S001	Publish Customer Order	S018	1	2	0	P02	1	1	2	2	2	1	25	S002	Consume Customer Order	S019	1	1	1	S003
SI002	Publish Order Ack to Customer B	2	1	1	1	04/07/08	S003	Publish Order Ack	S018	1	1	1	P02	1	1	2	2	1	1	15	S004	Consume Order Ack	S019	1	2	0	S000

Figure 7. Secondary Design Datasheet Sample – Designed During Pre-Study

Service Interaction							Originating Service (S_O)						CSB								Terminating Service (S_T)						
SI_ID	SI_DESC	SI_BUS_PAT	SI_DESIGN	SI_DEMO	SI_EVAL	SI_DEMO_DATE	S_O_BUS_ID	S_O_DESC	S_O_INT_ID	S_O_INV_TYPE	S_O_OWNER	S_O_BUS_ID_DES	CSB_VERSION	S_O_CONONICAL	S_T_CONONICAL	S_O_TRANSPORT	S_T_TRANSPORT	CSB_MSG_TYPE	CSB_TRANSFORM	CSB_DES_TIME	S_T_BUS_ID	S_T_DESC	S_T_INT_ID	S_T_INV_TYPE	S_T_OWNER	S_T_BUS_ID_DES	S_T_LINKAGE
SI092	Publish Stock-Check to eCommerce	2	1	1	1	03/06/12	S028	Publish Stock-Check	S033	2	1	2	P05	5	5	3	3	3	1	2	S091	Consume Stock-Check	S032	2	6	0	S028
SI093	Consume Field Credits from SugarCRM	4	1	1	1	03/15/12	S055	Publish Field Credits	S038	2	6	1	P06	5	7	3	3	1	2	12	S056	Consume Field Credits	S039	2	1	1	S000

Figure 8. Secondary Design Datasheet Sample – Designed During Study

A total of 56 unique service interactions were designed and implemented during the 18-month design-demonstration-evaluation phase of the study. This reflects an average rate of design of 3.1 service interactions per month as compared to 1.3 service interactions per month using traditional integration techniques. The descriptive statistics for the 56 service interactions, with a comparison to 39 legacy (pre-study) service interactions designs, are summarized in table 17. The average total design time for service interactions during the study period was 7.0 hours, 3.4 hours less than legacy designs. A total of 24 of the 56 service interactions (43%) required the design and development of one or more new business services, as compared to only 21% for legacy designs. The remaining 32 of the 56 service interactions (57%) used (or re-used) pre-existing business services to complete the design, as compared to 79% for legacy designs. The data indicates a 32% reduction in overall design time using the cloud integration platform relative to legacy integration methods – even with a lower rate of business service re-use (57% versus 79%), meaning more new design activity.

The distribution of service interaction design activities is categorized across four high-level business integration use cases. For the purposes of this study, electronic data interchange (EDI) and Master-File-Transfer-as-a-Service (MFTaaS) represent the traditional business integration approaches. Business integration use cases that leveraged web-services or cloud application programming interfaces (APIs) are considered as emergent. Of the 56 service interactions designed during the study, 21 used EDI and 7 used MFTaaS with average total design times of 4.5 and 5.1 respectively. A total of 11 service interactions used web-services and 13 used cloud-based API's with average total design times of 9.4 and 8.5 respectively. Collectively, designs that employed web-services and cloud API's had a 47% higher design time than the traditional EDI and MFTaaS use cases. Moreover, the results indicate higher variability in the overall design times for web-services and Cloud-based APIs with standard deviations of 6.8 and 4.8 as compared to EDI and MFTaaS with standard deviations of 3.5 and 2.3. The data indicates that service interaction designs conducted during the study had higher overall design times to accommodate emerging cloud-based business integration use cases. However, overall design times for all four use cases were lower than legacy design times.

	Pre-Study	Study	Business Services		Integration Use Cases			
			New	Reuse	EDI	MFTaaS	Web Service	Cloud API
COUNT	39	56	24	32	21	7	11	13
SUM	405.0	392.0	250.0	142.0	95.0	36.0	103.0	110.0
AVG	10.4	7.0	10.4	4.4	4.5	5.1	9.4	8.5
STD	4.6	4.9	5.2	2.5	3.5	2.3	6.8	4.8
MAX	25.0	22.0	22.0	10.0	15.0	10.0	22.0	18.0
MIN	4.0	2.0	4.0	2.0	2.0	4.0	2.0	4.0
RANGE	21.0	20.0	18.0	8.0	13.0	6.0	20.0	14.0

Table 17. Service Interaction Design Descriptive Statistics

As depicted in table 18 below, all 39 of the legacy service interactions addressed traditional business-to-business (B2B) use cases. Of the 56 service interactions designed and deployed in the study, a total of 22 addressed B2B uses cases, 31 addressed cloud-to-on-premise (C2P) use cases, 2 addressed application-to-application (A2A) use cases (i.e. integration of two on-premise business services), and 2 addressed cloud-to-cloud (C2C) use case (i.e. integration of two or more cloud-based business services).

	Pre-Study (Apr 08 – Sep 10)	Study Period (Oct 10 – Mar 12)
B2B	SI001, SI002, SI003, SI004, SI005, SI006, SI007, SI008, SI009, SI010, SI011, SI012, SI013, SI014, SI015, SI016, SI017, SI018, SI019, SI020, SI021, SI022, SI023, SI024, SI025, SI026, SI027, SI028, SI029, SI030, SI031, SI032, SI033, SI034, SI035, SI036, SI037, SI038, SI039 (**39**)	SI041, SI042, SI043, SI044, SI045, SI050, SI051, SI053, SI054, SI056, SI062, SI066, SI069, SI073, SI082, SI083, SI084, SI085, SI086, SI087, SI087, SI090 (**22**)
A2A		SI054, SI056 (**2**)
C2P		SI040, SI047, SI051, SI053, SI055, SI058, SI059, SI061, SI062, SI063, SI064, SI065, SI067, SI068, SI071, SI072, SI074, SI075, SI076, SI079, SI082, SI084, SI086, SI087, SI088, SI089, SI091, SI093, SI094, SI095 (**30**)
C2C		SI057, SI078 (**2**)

Table 18. Distribution of Service Interactions by Integration Use Case

Table 19 below depicts the distribution of the service interactions designed during the study by technical service interface. Technical service interfaces determine the method used to transmit the payload (i.e. file, data, message) to and from the underlying technical systems (i.e. application system, file system, database, enterprise service bus) to enable information exchange. The technical capability to enable business process integration with file systems, databases, web-services, and cloud API's is associated with the primary design activities, specifically the delivery of functionality in cloud platform versions P03, P04, P05, and P06. The most commonly used technical service interface used in the study was data file access

(30) followed by database access (22). The emergent technical services, cloud-based API's and web-services were used in 13 and 11 service interactions respectively.

	Service Interface Functionality Demonstrated
Datafile (P03)	SI041, SI042, SI043, SI044, SI045, SI046, SI047, SI048, SI049, SI050, SI051, SI052, SI053, SI054, SI056, SI059, SI061, SI065, SI071, SI072, SI077, SI080, SI081, SI082, SI083, SI084, SI085, SI086, SI087, SI088 (**30**)
Database (P04)	SI042, SI043, SI044, SI045, SI046, SI047, SI048, SI049, SI050, SI051, SI053, SI058, SI063, SI065, SI072, SI082, SI083, SI084, SI085, SI086, SI087, SI088 (**22**)
Web Service (P05)	SI055, SI060, SI068, SI070, SI074, SI075, SI076, SI079, SI091, SI092, SI095 (**11**)
Cloud API (P06)	SI057, SI058, SI059, SI061, SI063, SI064, SI067, SI071, SI072, SI078, SI089, SI093, SI094 (**13**)

Table 19. Distribution of Service Interactions by Technical Service Interface

The following tables (20 and 21) summarize the invocation and communications methods used in legacy service interactions and those created using the cloud integration platform in the study period. All legacy service interactions used a schedule-based invocation method as synchronous-type invocation methods (on-demand and event-driven) were not possible. The most common invocation method used in the design of service interactions during the study period was on-schedule (41), followed by synchronous options of on-demand (13) and event-driven (2).

	Pre-Study	Study Period	Total Count	Percent Total
On-Schedule	39	41	80	84.2%
On-Demand	0	13	13	13.7%
Event-Driven	0	2	2	2.1%
TOTAL COUNT	39	56	95	

Table 20. Distribution of Service Interactions by Invocation Method

The communication method describes the specific type of messaging standard and protocol employed to integrate two or more business services in a service interaction. Asynchronous communications are time delayed and can be one-way or two-way through initiation of a callback service that is processed at a later time. Synchronous communications are real-time and follow a request and reply model. Table 21 below summarizes the three types of communication messaging protocols used in the study. Asynchronous communications was the predominant messaging type. Synchronous communications was not available in the legacy environment and was designed into the cloud integration platform and used in 13 of the service interactions.

	Pre-Study	Study Period	Total Count	Percent Total
Asynchronous (One-Way)	26	38	64	67.4%
Asynchronous (Request/Callback)	13	5	18	18.9%
Synchronous (Request/Reply)	0	13	13	13.7%
TOTAL COUNT	39	56	95	

Table 21. Distribution of Service Interactions by Communications Method

In this study, the cloud services broker provided secure network connectivity and data transformation services to enable integration between business services. A total of 28 of the 39 service interactions in the pre-study used secure file transfer protocol (FTP/s) and 11 used the AS2 (Applicability Statement 2) standard. Of the 56 service interactions designed during the study, 42 used FTP/s and 1 used AS2. The hypertext transfer protocol over SSL (HTTP/s) was not previously available and was designed into the cloud platform. A total of 13 of the 56 service interactions designed during the study used the HTTP/s standard.

To enable network connectivity between two disparate business services, the cloud services broker may be required to provide data transformation services. During the study period, a total of 32 service interactions required no data transformation services (i.e. pass-through). A total of 24 service interactions required some level of data transformation services. The average design hours to establish network connectivity with transformation services is 9.3, 43% higher than the average design hours for service interactions without transformation.

	Total # of Service Interactions	Total Design Hours	Average Design Hours
Pass-Through	32	169	5.3
Transformation	24	223	9.3
TOTAL	56	392	7.0

Table 22. Distribution of Service Interactions by Transformation Services

This study seeks to demonstrate enhanced business process agility in terms of an increase in the range of business integration capabilities and a decrease in overall design time and speed of deployment. A factor contributing to reduced design time is the reusability of services in the orchestration and choreography of business processes. Table 23 below presents business process patterns that re-used one or more business services in their design and choreography. In 5 of the 6 business process patterns significant reductions in overall design time in the range of 32-86% are observed. The Publish Shipping Notification pattern did not exhibit linearity and was not calculated. As described previously, 57% of the service interactions re-used one or more business services in their design.

Business Pattern	Service Interaction (ID, Demo Date, Design Hours)						Design Trend
Consume Customer Order	SI040	SI047	SI064	SI082			-63%
	10/15/10	02/01/11	07/01/11	02/01/12			
	6.0	4.0	4.0	2.0			
Consume Freight Rate	SI074	SI075	SI076	SI078			-53%
	11/01/11	11/15/11	11/17/11	12/15/11			
	8.0	4.0	4.0	4.0			
Consume Inventory	SI048	SI077	SI080	SI081			-32%
	02/01/11	12/01/11	01/15/12	01/20/12			
	6.0	4.0	4.0	4.0			
Publish Invoice	SI042	SI051	SI066	SI069	SI086	SI087	-82%
	11/15/10	02/14/11	07/01/11	08/01/11	02/15/12	02/15/12	
	10.0	2.0	4.0	4.0	2.0	2.0	
Publish Shipping Notification	SI053	SI059	SI062	SI067	SI088		NA
	02/17/11	04/07/11	05/15/11	07/01/11	02/17/12		
	2.0	10.0	4.0	4.0	2.0		
Publish Stock-Check	SI055	SI060	SI070	SI079	SI091	SI092	-86%
	03/01/11	04/10/11	09/01/11	01/05/12	03/01/12	03/06/12	
	20.0	10.0	8.0	6.0	4.0	2.0	

Table 23. Service Interactions with Business Service Re-Use Patterns

This study sought to demonstrate increased range agility in the design of multi-enterprise business processes using the cloud integration platform. A canonical is a type of design pattern used to exchange information between disparate business processes, thus the more canonicals supported the wider the range of integration capabilities. Table 24 presents the canonicals types used to design the 56 service interactions. The most common canonical in the study is EDI ANSI 4010 used in 38 of the originating and terminating business services. The second most often used canonical type was the XML standard (27), followed by the file standard (19), Cloud APIs (12), OAGIS (6), BAI (4), papiNet (3), and xCBL (2).

	S_0_CONONICAL	S_T_CONONICAL	TOTAL	TOTAL %
EDI	21	17	38	33.9%
OAGIS	2	4	6	5.4%
papiNet	2	2	3	3.6%
BAI	4	0	4	3.6%
XML	15	12	27	24.1%
xCBL	0	2	2	1.8%
Cloud API	4	8	12	10.7%
File	8	11	19	17.0%
TOTAL	56	56		

Table 24. Distribution of Service Interactions by Canonical Type

In part, range agility is achieved through combinations (i.e. mash-ups) of different types of business services. Presented in table 25 is a sample of service interactions designed in this study that include combinations or mash-ups of traditional business services (i.e. EDI, File) that are orchestrated with emerging business services (i.e. XML, Cloud API) from cloud service providers.

ID	Service Interaction Description	Demo Date	Design Hours	S_0 Canonical	S_T Canonical
SI047	Consume Orders from Amazon.com	2/04/11	4.0	Cloud API	EDI
SI057	Publish Customer to SugarCRM	3/20/11	8.0	OAGIS	Cloud API
SI058	Consume Invoices from MercuryGate	4/01/11	8.0	Cloud API	OAGIS
SI063	Consume Credit Cards from Authorize.Net	6/01/11	18.0	Cloud API	File
SI068	Consume Currency from StrikeIron	7/15/11	15.0	Web Service	Web Service
SI074	Consume Freight Rate from MercuryGate	11/1/11	8.0	Web Service	Cloud API
SI089	Publish Quotes to SugarCRM	2/20/12	12.0	File	Cloud API
SI093	Consume Field Credits from SugarCRM	3/15/12	12.0	Cloud API	EDI
SI095	Publish URL to SugarCRM	4/1/12	22.0	Web Service	Web Form

Table 25. Service Interactions Using Combinations of Business Services

4.4.2 Secondary Designs – Business Context

In a typical manufacturing enterprise customer value is created through the design of an integrated set of business processes across the demand chain, supply chain, and network of manufacturing, logistics, financial, and cloud service providers. Research has shown that the firm's range of business integration capabilities and speed of deployment across their value network is an important competency for sustained competitive advantage (Sher and Lee, 2004; Ozgur et al., 2009; Lee et al., 2010). For the purposes of this study, a service value network is an integrated demand chain and supply chain, where the demand chain consists of processes that generate customer demand and the supply chain consists of processes that transform raw materials into finished goods (or services) from the supplier to customer.

The 39 pre-study (legacy) service interactions migrated to the cloud integration platform and the 56 newly designed service interactions represent a service value network consisting of customers, suppliers, business partners, and cloud providers. Table 26 below depicts the distribution of service interactions across the service value network by the type of business partner. The supply chain is represented by distribution (DIST), manufacturing (MFG), and logistics (LOG) processes. The demand chain is represented by price and availability (P&A), web-based electronic commerce (WEB), and customer relationship management (CRM) processes. Financial (FIN) and other miscellaneous (MISC) processes complete the service value network. The total number of pre-study service interactions is indicated in (BLACK) and service interactions designed during the study are indicated in (RED).

		Supply Chain			Demand Chain					
		DIST	MFG	LOG	P&A	WEB	CRM	FIN	MISC	TOT
Business Partners	Customer	19 | 1	0 | 0	2 | 0	0 | 2	0 | 0	0 | 0	4 | 4	4 | 0	27 | 7
	Manufacturing Partner	0 | 0	0 | 7	0 | 1	0 | 0	0 | 0	0 | 0	0 | 2	0 | 0	0 | 10
	Logistics Partner	0 | 0	0 | 0	10 | 2	0 | 0	0 | 0	0 | 0	0 | 0	0 | 0	12 | 2
	Financial Partner	0 | 0	0 | 0	0 | 0	0 | 0	0 | 6	0 | 0	0 | 4	0 | 0	0 | 4
	Cloud Service Provider	0 | 0	0 | 0	0 | 4	0 | 4	0 | 10	0 | 4	0 | 10	0 | 1	0 | 29
	Other	0 | 0	0 | 0	0 | 0	0 | 2	0 | 0	0 | 0	0 | 1	0 | 1	0 | 4
	TOTAL	19 | 1	0 | 7	12 | 7	0 | 8	0 | 16	0 | 4	4 | 21	4 | 2	39 | 56

Table 26. Distribution of Service Interactions by Business Partners

As summarized in table 26 above, the pre-study service interactions exclusively addressed traditional supply chain (distribution and logistics) and financial business processes with customers and logistics providers. Whereas, the service interactions designed during the study using the cloud integration platform pursued business processes across the service value network. A total of 29 of the 56 (52%) service interactions involved one or more cloud service providers, 18 (32%) integrated business processes in the demand chain, 21 (38%) integrated financial business processes, and 10 (18%) integrated manufacturing partners into the supply chain. Service interactions in the other category include application-to-application (A2A) and system-to-system integration use cases scenarios. Further insight into the business context of this network of service interactions is provided in the following sections.

Figure 9 below is a representation of Mohawk as a service-oriented enterprise consisting of 96 multi-enterprise business processes enabled by the cloud integration platform. The cloud integration platform provides seamless integration of the capabilities of the enterprise with a network of customers, suppliers, manufacturers, logistics providers, financial institutions, and cloud service providers. Collectively, these business processes have expanded Mohawks product and service offerings, extended and streamlined supply chain operations, enabled new web-based platforms for commerce, and expanded access to customers. Several thousand digital transactions are processed per day through the cloud business integration platform to include application-to application (A2A), business-to-business (B2B), cloud-to-on-premise (C2P) and cloud-to-cloud (C2C) use cases.

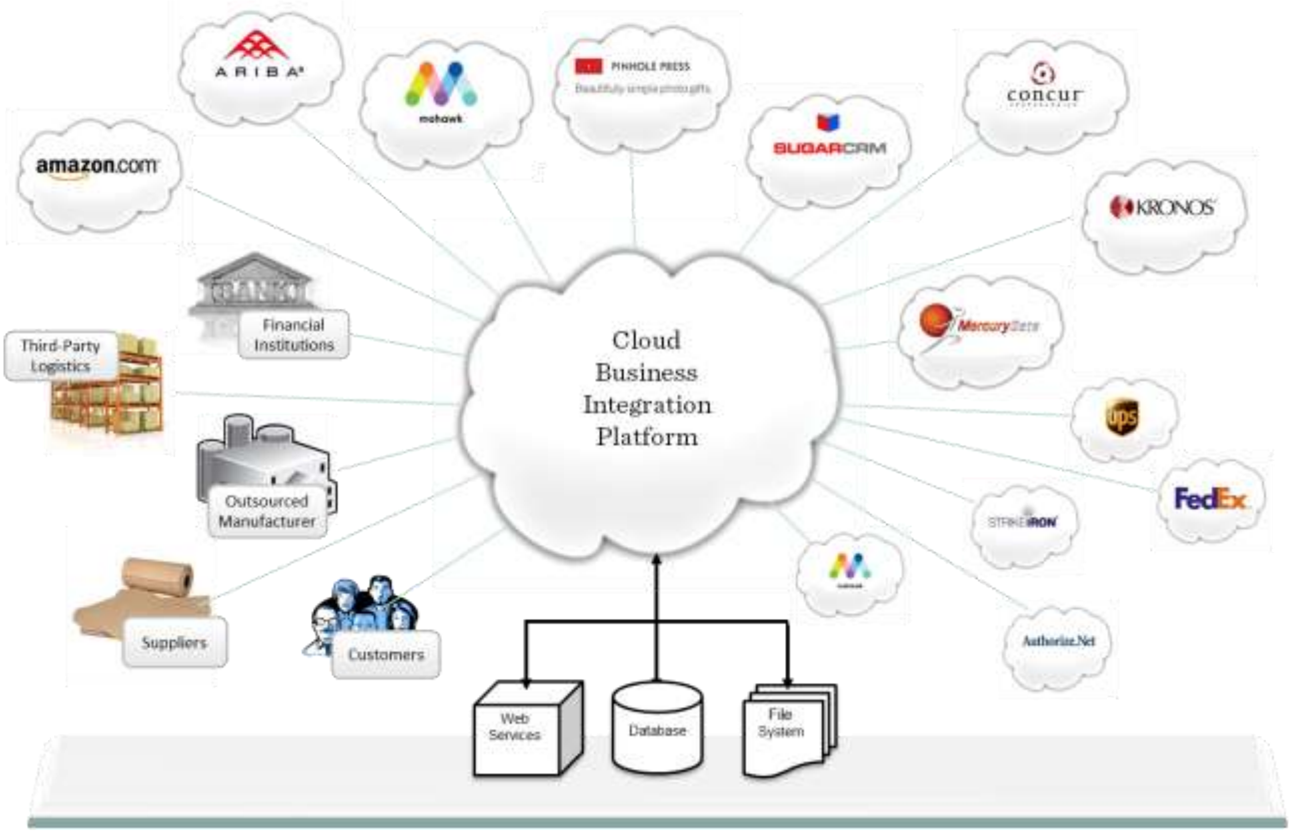

Figure 9. Service-Oriented Enterprise Enabled by the Cloud Integration Platform

In the remainder of the section, insight is provided into the business context of the service interactions designed during the study and their collective contribution to the realization of the business strategy to enable Mohawk's transition towards a service-oriented enterprise. The presentation of results on the business context of the service interactions is organized into the categories of supply chain, demand chain, and financial business processes.

Supply Chain Business Processes. The supply chain is a set of business processes that move products (and services) from suppliers to customers. The supply chain consists of suppliers, manufacturers, logistics providers, and the customers themselves. In the context of this study, supply chain business processes focused on interactions with Mohawk's traditional customers (paper merchants), interactions with outsourced manufacturing partners who supply products and services, and third party logistics providers who manage inventory and transport products (listed as DIST, MFG, and LOG respectively in table 26). Each of these supply chain categories are described in the context of the service interactions designed pre-study (BLACK) and during the study (RED).

Prior to the study, a total of 19 service interactions were designed to integrate Mohawk's internal business processes with those of traditional customers (e.g. the paper merchants). These service interactions enabled the receipt of customer orders from customers and the issuance of order acknowledgements. These service interactions were transacted using EDI protocols. In terms of business impact, these service interactions automated the receipt of the majority of customer orders, thereby resulting in reductions in staffing requirements as well as improving the speed of order fulfillment. The service interactions represented in the supply chain distribution (DIST) category are: [SI001, SI002, SI003, SI005, SI006, SI007, SI008, SI018, SI019, SI020, SI021, SI022, SI023, SI024, SI025, SI026, SI031, SI033, SI034, SI035, SI038, SI041].

As part of Mohawk's transition towards a service-oriented enterprise, the business strategy called for a streamline of it production capacity and the pursuit of more diverse and higher margin business products and services. Mohawk closed one of its production facilities that produced lower margin products and established partnerships with other manufacturers to produce similar products at lower cost. Mohawk pursued an envelope converting capability as a high-margin complement to paper manufacturing capabilities. This was accomplished by the rapid on-boarding of manufacturing partners and their seamless integration into Mohawks internal business operations. During the study, seven service interactions were designed and implemented to integrate manufacturing partners into Mohawks internal business processes. These business processes enabled the electronic exchange of customer orders, product specifications and the synchronization of partner production schedules. The business impacts resulting from the execution of an outsourced manufacturing strategy has been significant in terms of lower operating cost and increased profitability. The service interactions represented in the supply chain manufacturing (MFG) category are: [SI044, SI048, SI077, SI080, SI081, SI083, SI090].

The final category within the supply chain business processes is logistics. This represents business processes that integrate third-party logistics providers and transportation carriers who inventory and transport products on behalf of the enterprise. This category provides a blend of traditional and emerging cloud-based business integration use cases. A total of 12 service interactions designed prior to the study, but later migrated to the cloud integration platform, seamlessly integrated two domestic and one international third-party warehouses with Mohawk's internal business processes. Using traditional EDI, customer orders were electronically routed to the appropriate warehouse for order fulfillment. These third-party logistics partnerships have enabled Mohawk to extend the network of its products across North America and to Europe. During the study, logistic capabilities were further enhanced by leveraging a cloud-based transportation management system (TMS) called MercuryGate. MercuryGate manages the shipment of products to/from customers and warehouses using a network of transportation carriers. MercuryGate receives payment information from the transportation carriers via EDI which is integrated with Mohawk systems for payment. In addition, MercuryGate provides a Rating-as-a-Service (RaaS) capability for use by internal Mohawk systems and cloud-based eCommerce platforms to provide real-time quotes for shipment. The rating business service is routed through the cloud platform and represents a cloud-to-cloud integration use case (MercuryGate to eCommerce) and an example of cloud arbitrage by determining the freight rate (i.e. LTL, UPS, and FedEx). The interoperability with the third-party logistics providers and cloud-based transportation management system has significantly expanded Mohawk's market reach and access to new customers. The service interactions represented in the supply chain logistics (LOG) category are: [SI004, SI009, SI010, SI011, SI012, SI013, SI014, SI015, SI016, SI027, SI028, SI036, SI067, SI074, SI075, SI076, SI078, SI085, SI088].

Demand Chain Business Processes. The demand chain is an integrated set of business processes that create and sustain customer demand for the firm's products and services. Demand chain business processes are customer-facing and involve sales, marketing and support activities. In the context of this study, demand chain business processes are service interactions related to price & availability (P&A), web or electronic commerce (WEB), and customer relationship management (CRM). At the fundamental level, demand is the price and quantity of a product or service desired by a given customer. For Mohawk, an essential element of demand generation is based on the capability to provide transparent pricing and real-time visibility into inventory levels at a specified time and location. A total of 8 service interactions were designed in the study to enable real-time access to price and availability information via cloud-based business services. The price and availability business services access information directly in Mohawk's enterprise system for consumption in Mohawk's eCommerce web-sites, customer web-sites, internal purchasing systems, and using mobile applications for BlackBerry, Android, and iPhone. Approximately 50,000 web-service calls for price and availability are transacted monthly using the cloud platform, returning results in 1-2 seconds. The business impact resulting from this business capability is significant and has resulted in increased eCommerce sales directly from new types of customers. This capability has also delivered significant operational benefits as 50% of the call volume into the Mohawk's call center has been eliminated, thereby enabling a focus on higher value activities and staff overall reductions. The service interactions represented in the demand chain price and availability (P&A) categories are: [SI041, SI055, SI060, SI061, SI070, SI079, SI091, SI092].

As discussed in the Introduction Chapter, for many decades Mohawk's business model was based on selling paper products to distribution (paper merchant) for direct sale to designers, printers and end-user customers. A fundamental component of Mohawk business strategy transformation was to sell products and services directly to business and retail customers using eCommerce platforms. In response, Mohawk pursued the development of a number of eCommerce web-sites (MohawkConnects.com, FeltandWire.com, and PinholePress.com) requiring integration to Mohawk's internal operations for order fulfillment. Additionally, Mohawk established business partnerships with the online retailers Amazon and Ariba to offer its products to small and medium sized businesses and retail consumers. A total of 10 service interactions were designed during the study to receive customer orders from the eCommerce web-sites, via the cloud platform, for direct fulfillment using Mohawk internal systems. The eCommerce web-sites and on-line marketplaces used traditional EDI as the canonical type to enable business process integration. Collectively, the deployment of the eCommerce web-sites and their integration with internal business processes has resulted in new demand and revenue for Mohawk products. The service interactions represented in the demand chain eCommerce (WEB) category are: [SI047, SI050, SI055, SI057, SI061, SI064, SI065, SI082, SI084, SI089, SI092, SI094, SI095].

The demand chain is often associated with Customer Relationship Management (CRM) systems and related business processes. For the purposes of this study, CRM is defined as a business strategy supported by technology designed to manage the enterprises interactions with customers and potential customers for the purposes of generating demand for products and services. As part of Mohawk's business strategy transformation, the number and types of potential customers would increase significantly, from several hundred merchants to many thousands of direct businesses and consumers. To manage the increase in customers, Mohawk implemented the cloud-based customer relationship management (CRM) solution SugarCRM. To effectively leverage SugarCRM for demand creation the system needed to be seamlessly integrated with internal business processes, as well as Mohawk's cloud-based eCommerce platforms. During the study, a total of 4 service interactions were designed and implemented using the cloud integration platform. Two of the service interactions focused on the integration of customer quotes between SugarCRM and Mohawk's enterprise system.

Quotes are automatically transferred from the on-premise ERP system to SugarCRM for real-time visibility and follow-up by the sales force. A third service interaction enabled the processing of customer credits between SugarCRM to the ERP system. A fourth service interaction enabled real-time visibility of order status within SugarCRM by calling a web-service that accessed Mohawk's enterprise system. The implementation of the cloud-based SugarCRM and its integration with internal business processes has been a key enabler of Mohawk's business strategy, and in particular the transformation of Mohawk's sales team and associated selling processes. The service interactions represented in the demand chain customer relationship management category are: [SI057, SI089, SI094, SI095].

Financial and Governance Business Processes. This section provides the business context for financial and governance business processes. For the purposes of this study, financial processes include activities associated with general ledger, accounts payable and accounts receivable. This category represents the largest number of service interactions designed and developed during the study. A total of 10 service interactions were designed to automate the issuance of invoices to customers, the receipt of invoices from suppliers, the receipt of cash transactions from financial institutions, all flowing through the cloud integration platform using standard EDI protocols. A total of 10 service interactions involved the integration of cloud service providers with the Mohawk's internal finance and accounting systems. These service interactions included the processing of transactions from the cloud-based expense management system Concur, the receipt of invoices from the cloud-based transportation management system MercuryGate, the receipt of eCommerce credit card transactions from the cloud-based merchant Authorize.Net, and the receipt of invoices from the cloud-based marketplaces Amazon and Ariba. An additional and unique service interaction involves StrikeIron, a cloud-based aggregator of web-services. In this service interaction, at the point of shipment of an international order a web-service is called at StrikeIron through the cloud platform to calculate the currency exchange. This business process ensures that accurate and favorable exchange rates are reflected on international customer invoices. Collectively, these 21 service interactions automated the majority of Mohawk financial transactions with business partners, resulting in reduced staffing, faster and more accurate cash management, and enabling the adoption of several financial software-as-a-service (SaaS) applications. The service interactions represented in the financial (FIN) category are: [SI017, SI032, SI037, SI039, SI042, SI043, SI045, SI046, SI049, SI051, SI052, SI053, SI054, SI058, SI059, SI062, SI063, SI066, SI068, SI069, SI071, SI072, SI073, SI086, SI087, SI093].

A number of service interactions designed in the study are classified as administrative or governance business functions. The first service interaction in this category involves the implementation of the cloud-based human resource management system Kronos. During the study period, Mohawk decided to transfer the on-premise instance of Kronos (e.g. time and attendance, human resource, and payroll functions) to the cloud to address support and system issues. A service interaction was designed to extract employee information from the cloud-based Kronos application to an on-premise database for analysis and reporting and to enable user authentication in Mohawk's internal systems. A series of service interactions in this category include application-to-application (A2A) integration use cases. These service interactions involved the system-to-system integration of vendor information and invoices between Mohawk's enterprise resource planning (ERP) and enterprise asset management system (EAM). When a vendor is added to the on-premise EAM system a web-service is called through the cloud platform to insert the vendor information in the ERP system. The service interactions represented in the miscellaneous (MISC) categories are: [SI054, SI056, SI065, SI079, SI091].

4.5 Research Study Communications

The Communications Phase of the design science research in information system process requires that the researcher communicate the research problem and its importance, the technical details of the designed IT artifact, its utility and novelty, the rigor of design, and its effectiveness to researchers and professional audiences. During the two-year study, there were a number of opportunities to communicate the research motivation, progress, findings, and conclusions.

Communication to academic audiences consisted of the public thesis proposal defense, the body of work presented in this doctoral thesis, and the public defense of this research. The communication of research intentions, progress and results to the practitioner community consisted of industry case studies (Gartner InfoTrends), four presentations at professional conferences, three interviews captured in podcasts and trade articles, and the forward of *Cloud Service Brokerage for Dummies* (Copyright © 2012 by John Wiley & Sons, Inc.). In table 27 below, the communications events have been documented by date, venue, and the target audience.

ID	Date	Communications Event	Target Audience
1	10/01/10	Blog Interview Thought Leaders in Cloud Computing	Management-Oriented Practitioners
2	01/28/11	Thesis Proposal Defense at Syracuse University Syracuse, NY	Academic Researchers
3	04/11/11	Presentation at Liaison Converge Conference, Atlanta, GA	Management-Oriented Practitioners
4	06/01/11	Gartner Case Study on Mohawk Cloud Services Brokerage	Management-Oriented Practitioners
5	12/04/11	Presentation at Gartner ADDI Conference Las Vegas, NV	Technology-Oriented Practitioners
6	03/01/12	InfoTrends Case Study Mohawk Paper Transformation	Management-Oriented Practitioners
7	03/20/12	Interview with Computerworld Magazine Feature Article	Management-Oriented Practitioners
8	04/01/12	Published Forward Cloud Services Brokerage for Dummies	Management-Oriented Practitioners
9	04/04/12	Presentation at CIO-Midmarket Conference Orlando, FL	Management-Oriented Practitioners
10	04/15/12	Presentation at Liaison Converge Conference, Atlanta, GA	Management-Oriented Practitioners
11	05/01/12	Podcast Interview CIO-MidMarket Forum	Management-Oriented Practitioners
12	03/25/12	Thesis Defense Syracuse University Syracuse, NY	Academic Researchers

Table 27. Events and Venues to Communicate Research Progress

4.6 Summary of Results and Findings

The results from the study were presented in the sequence of the design science research in information systems process. As described in the Introduction Chapter, the motivation for this research was to enable the transition a medium-sized manufacturing firm towards a service-oriented enterprise by delivering enhanced levels of business process agility. The assessment of six leading and emerging business integration solution providers concluded that they did not sufficiently address all the business integration requirements in the case study environment. Thus, to address the business problem and gap in the solutions space, the design of a more robust and cost effective business integration solution was pursued. The business and technical objectives of the desired artifact were established by a team of representatives from Mohawk, Liaison Technologies, and AgilePath. The resulting solution objectives were embodied in ten guiding design principles which leveraged the converged benefits of service-oriented architecture and cloud computing.

In an eighteen month period between October 2010 and March 2012, the study pursued two interrelated primary and secondary activities. Primary design activities pursued the design, demonstration, and evaluation of a cloud integration platform and repository of business and technical services. The cloud integration platform capabilities were released in six consecutive phases of incremental functionality based on feedback from secondary design activities. The evolution of the cloud integration platform functionality commenced with the provisioning of the cloud infrastructure as virtual resources, the establishment of secure network connectivity between the cloud broker and Mohawk's private cloud, followed by the design and development of a series technical services to enable seamless interoperability with file systems, databases, web-services, and cloud APIs. As part of the primary design, a repository of 46 business services were designed and made available in a cloud-based business service registry for discovery and orchestration to form service interactions that result in multi-enterprise business processes.

Secondary design activities leveraged the capabilities of the cloud integration platform and repository of technical and business services to design and deploy a wide range of service interactions. As described, service interactions integrate two business services (regardless of their location or underlying technology) through the cloud integration platform to form a multi-enterprise business process (an activity that produces business value). The results and findings from the study sought to answer the research question, how does a cloud-based architecture enable enhanced business process agility in a medium-sized manufacturing enterprise? In this study, business process agility is operationalized in terms of the range of integration capabilities and the speed of deployment of multi-enterprise business processes. The results from the secondary design activities were first presented in a technical context (i.e. communication, invocation, and translation capabilities) and then in a business context to inform the notion of value propositions and service value networks.

During the study, a total of 56 service interactions were designed, developed and deployed as multi-enterprise business processes. A total of 39 service interactions designed prior to the study were migrated to the cloud integration platform and provided a basis for comparison of business integration capabilities and speed of deployment. The design, development, and implementation of the service interactions adhered to the guiding principles of the service-oriented architecture and cloud computing deployment models. The service interactions designed during the study leveraged the cloud platform to address all required business integration use cases (i.e. B2B, A2A, C2P, and C2C). The service interactions demonstrated a wide-range of technical capabilities to accommodate traditional business-to-business and cloud integration requirements. These technical capabilities included synchronous and asynchronous communications methods, eight canonicals standards (e.g. EDI, XML Cloud APIs, OAGIS, BAI, papiNet, and xCBL), and three types of service invocations methods (e.g. on-demand, event-driven, and scheduled). Collectively, this range of technical capabilities enabled the seamless integration of on-premise and cloud-based file systems, databases, web-services, and cloud APIs without regard to their underlying technology and location.

The results demonstrated reductions in the design time and faster time to deployment for multi-enterprise business processes relative to prior integration methods and within the study period. Service interactions were designed and deployed at a rate of 3.1/month prior to the study and at a rate of 1.3/month during the study period, a 58% increase. The average design time for service interactions designed prior to the study was 10.4 hours and 7.0 hours during the study, a reduction of almost 33%. Service interactions that addressed traditional business integration use cases (i.e. EDI and MFTaaS) had 50% lower overall design time than those designed prior to the study. Service interactions that addressed emerging cloud-based business integration use cases (i.e. web-services and cloud APIs) exhibited the highest overall design times, but lower than the average design time pre-study. Service interactions designed during the study that re-used business services exhibited significant reductions in overall design time and speed of deployment, a decrease in the range of a low 30% and a high of 80% depending on the type of service interaction pattern.

A service interaction is a technical integration of two business services to form a business process. A service interaction becomes a business process when described in the context of the set of work activities that deliver business value. As part of the presentation of results, insight was provided into the business value of the service interactions designed during the study in terms of supply chain, demand chain, and financial business processes. The 39 pre-study (legacy) service interactions provided significant business value for traditional supply chain processes to automate the processing of customer orders and invoices. The 56 new service interactions designed during the study delivered business value across supply chain, demand chain, and financial processes. Approximately one-half of the service interactions leveraged the competencies of cloud providers, one-third pursued demand generation, and one-quarter enabled collaboration with manufacturing partners. Collectively, the 95 multi enterprise business processes operating on the cloud-based integration platform generated millions of dollars in operational savings and millions of dollars in additional revenue.

The presentation of results concluded with an overview of communications activities as required in the design science research in information systems process. Over the two-year period, this researcher communicated this study's motivation, progress, and contribution to professional and academic audiences on eleven occasions. The events and venues spanned professional conferences, industry case studies, trade interviews, and the public defense of this research study.

CHAPTER 5

RESEARCH CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

5.0 Chapter Overview

This final chapter of the doctoral thesis presents an overall analysis and integration of the research findings leading to a discussion of the research study's significance, contribution, and implications for practitioners and future scholarly research. The chapter is organized in three sections, a conclusion, discussion, and recommendation section. The conclusion section begins with a summary of the research motivation, agenda, question and the results and findings emerging from the study. Based on the study results, findings and applicable literature, conclusions are presented to address the research agenda and research question. The discussion section provides a forum to interpret the findings and conclusions and relate them to the motivation of the study and the applicable scholarly research. The discussion is presented from two main perspectives of design science research in information systems. First, how did the IT artifact designed in the study address the research problem in a new way and second what contributions this study make to the scholarly knowledge base of design. The chapter concludes with a presentation of recommendations that emerged from the study and the potential areas for future research. The recommendations are targeted to information technology and business professionals considering service-oriented design techniques and methods to enable digital integration and collaboration with a network of business partners for the purposes of value creation for the enterprise and its customers.

5.1 Research Study Conclusions

This two-year case study research followed the business and technology transformation of Mohawk, a medium-sized paper manufacturing firm, towards a service-oriented enterprise. In response to highly disruptive market forces and competitive threats, Mohawk embarked upon a business strategy to augment its internal core competencies with those of a network of business partners to reach new customers and offer them new and compelling products and services. The motivation for this research study was to pursue an aligned business and technology strategy to enable Mohawk's transition towards a service-oriented enterprise capable of effectively integrating its business processes across and beyond the enterprise. The objective was to design a new and cost effective approach to compose, orchestrate, and choreograph multi-enterprise business processes to establish dynamic service systems and value networks capable of delivering incremental value propositions to customers beyond those capable by the enterprise alone.

The main thesis of this study was that the transition towards a service-oriented enterprise by a medium-sized manufacturing firm with a progressive approach to technology adoption, but with limited technical and financial resources, could be achieved through the design and implementation of a cloud integration platform. The design of a cloud integration platform would exploit the benefits of a service-oriented architecture and cloud computing to enable the enterprise to deploy a range of flexible multi-enterprise business processes. A review of the scholarly and professional literature revealed that the notion of cloud integration is a nascent and emerging topic, where the literature only provides conceptual frameworks and lacks insight into application in practice. To address the gaps in the literature and practice, this study pursued the design and demonstration of a cloud integration platform to enable the cost effective design and deployment of flexible multi-enterprise business processes. In this context, the research question explored how an emerging cloud-based architecture can enhance business process agility in a mid-sized manufacturing enterprise. In this study, business process agility was operationalized as the range of integration capabilities and the time (and cost) to design and deploy a range of multi-enterprise business processes. In the larger context of the research agenda, the enhanced business process agility afforded by the cloud integration platform was investigated as an enabler of Mohawk's transition towards a service-oriented enterprise.

To answer the research question and provide insight into the broader phenomenon of the service-oriented enterprise, a design science research in information systems methodology was employed. Design science research in information systems is fundamentally a problem solving process with the goal to design and evaluate an IT artifact to solve an organizational problem in a unique or innovative way. In this research study, the problem was pursued in two interrelated design phases. A primary phase that pursued the design a cloud integration platform and a secondary phase where the enterprise leverages these platform capabilities to design and deploy a diverse range of multi-enterprise business processes. As prescribed by the design science research in information system methodology, insight into constructs, methods, and models emerging from the conduct of the research are then communicated to relevant academic and professional audiences in the form of actionable recommendations and potential for future research.

During the eighteen-month period between October 2010 and March 2012, a cloud-based service-oriented infrastructure and cloud services brokerage model (collectively, the cloud-based business integration platform) was designed and implemented. Using this platform, 56 multi-enterprise business processes were designed and deployed. In addition, 39 legacy multi-enterprise business processes were migrated to the cloud-based integration platform. The results suggest enhanced levels of business process agility in terms of the rate and speed of design and deployment of multi-enterprise business processes relative to prior methods used in the case study environment. The cloud integration platform resulted in a 58% faster rate of deployment and a 33% reduction in overall design time relative to pre-study methods. Overall design times were reduced in the range of 32%-86% for business processes that reused pre-existing business services. The enhanced levels of business process agility were achieved at a total cost of ownership that is more aligned with the resources available in a medium-sized enterprise. During the study, the total hours expended by the cloud services broker to develop and deploy the 56 multi-enterprise business processes was 392 hours or a total cost of approximately $30,000 over an eighteen month period, representing a fraction of the cost to purchase and manage an on-premise enterprise-class business integration solution.

As described, the motivation for this study was to enable Mohawk's business transition towards a service-oriented enterprise that leverages a network of business partnerships to offer its customers with new products and services. The cloud-based integration platform designed and implemented during the study provided the foundation for business process agility to integrate partner capabilities. Thus, meaningful insight emerging from the study relates to the business benefits associated with the orchestration of business processes and the choreography of collections of multi-enterprise business processes to achieve an overall business strategy. The business benefits resulting from the 56 service interactions designed and implemented during the study were highly significant. In general terms, the business processes designed and deployed in the study can be categorized as providing operational benefits and/or revenue generation benefits. The 39 service interactions designed prior to the study, and migrated to the cloud platform during the study, focused on traditional supply chain business processes resulting in improved operational and transactional efficiency for both the enterprise and the collaborating partner. Whereas, the 56 new service interactions designed in the study delivered business benefits across supply chain, demand chain, and financial processes. In particular, one-third of these service interactions supported demand chain processes to generate additional revenue. One-quarter of the new service interactions supported supply chain processes designed to integrate manufacturing partners to produce lower margin products and to expand Mohawk's product and service portfolio.

The integration of the capabilities of cloud-based service providers with Mohawk's internal business processes, representing half of the service interactions designed during the study, resulted in significant business value. By integrating the capabilities of cloud marketplaces from Amazon, Ariba, and Google, new markets and channels were established for Mohawk's products and services. A suite of eCommerce web-sites were developed and integrated into Mohawk's internal business processes to fulfill orders directly to retail customers and small businesses. A collection of service interactions were designed and implemented to integrate the cloud-based marketplaces and eCommerce websites with internal business processes to provide real-time information (i.e. pricing, item availability, freight quotes), to receive and process customer orders for fulfillment, and to ship products to customers. In addition, service interactions were designed and developed to support the online selling platforms by integrating cloud-based service providers to support sales & marketing business processes (SugarCRM), financial & accounting business processes (i.e. Authorize.Net, StrikeIron), and transportation management processes (MercuryGate). The collection of the 39 legacy and 56 new service interactions integrated traditional business-to-business (B2B) processes with emerging cloud-based business processes to form a comprehensive and robust service value network. The cloud integration platform was a key enabler of Mohawk's transition to a service-oriented enterprise over the two-year study period resulting in millions of dollars in operational savings and millions of dollars in additional revenue.

The business benefits realized from the cloud integration platform have been acknowledged by Mohawk's Chairman & CEO Thomas D. O'Connor, Jr. In a press release in April 2012 entitled *"Mohawk Reinvents the Way it does Business, Transforms Face to the World"*, Mr. O'Connor credited the cloud platform as the enabler of Mohawk business transformation. He described the transformation as "one that promotes partnerships designed to respond to changing customer demands for new and innovative products and services." Mr. O'Connor also credits Mohawk's transition towards service-orientation as the basis of the agility to respond to current and future changes in the marketplace. He described the cloud platform designed in this study "as a sturdy base and flexible structure from which to lead change in the paper industry." Adding further that "this strategy is the beginning of a revolution in the way we conduct business and who we do business with and represents his commitment to build a company that is highly responsive to changes in the marketplace."

The results, findings, and contributions from this research have received acknowledgement from leading IT advisory and consulting firms as being innovative and highly relevant to IT practitioners. InfoTrends, a market research and strategic consulting firm focusing on the digital imaging and document solutions industry, published research on Mohawk's business transformation (InfoTrends, 2012). In their research "*Mohawk Fine Paper - Transforming for the Future*" they found that "Mohawk's investment in a cloud-based supply chain and e-commerce platforms increased its flexibility, agility and effectiveness, while also creating opportunities to sell higher-margin products and services directly to end customers." Moreover, their research findings suggest that Mohawk "provides important lessons on how senior management should rethink their business and transform their company."

Deloitte, a leading IT advisory and consulting firm, cited the outcomes from this research in their 2012 Tech Trends Report (Deloitte, 2012). In the report entitled "*Elevate IT for Digital Business*" Deloitte described Mohawk "as a lesson from the frontline in the world of hyper-hybrid clouds by leveraging an approach that combines on-premise enterprise assets with multiple cloud services using an enhanced set of technology disciplines."

Gartner, a leader in IT research and advisory services, published a case study on Mohawk's use of the cloud platform (Lheureux, 2011). In their research report entitled "*Mohawk Fine Papers Uses a CSB to Ease Adoption of Cloud Computing*", they write that "Mohawk took a holistic approach to achieve multi-enterprise business process agility across its extended enterprise by seeking a comprehensive approach to its integration and SOA strategy for A2A, B2B and cloud computing." The Gartner report concludes that "Mohawk provides important lessons for anyone considering Cloud Services Brokerage", which they described as the "single largest growth opportunity in cloud computing" (Plummer, 2009).

The results and contributions from this research received a number of prestigious industry accolades for its innovation and relevance to practitioners. In April 2012, Mohawk received a Technology Innovation Award from Mid-Market CIO, citing the results from the research study as the most innovative among global mid-sized enterprises. In May 2012, Mohawk received the prestigious CIO 100 award from CIO magazine citing Mohawk as one of the 100 most innovative organizations that uses IT effectively to create business value.

In conclusion, the results and findings from this study demonstrated how a medium-sized manufacturing enterprise leveraged a cloud integration platform to enable the agile design and deployment a wide range and combination of multi-enterprise business processes. The research study results demonstrated how inter-organizational business processes can be composed, orchestrated and choreographed to form a service value network to integrate the capabilities of the firm with those of complementary business partners and service providers. Mohawk's transition to a service-oriented enterprise, enabled by the cloud integration platform, has resulted in significant business benefits in terms of increased operational efficiencies and revenue generation. The research outcomes have been recognized for their innovativeness and relevance by a number of IT advisory, consulting and media firms. In the following section, the study's findings, outcomes and conclusions are discussed in the context of the relevant scholarly research and potential contributions to practitioners and the knowledge base of service-oriented design.

5.2 Research Study Discussion

The discussion section serves as a forum to provide interpretations of the study's findings and conclusions in the context of the research agenda and relevant scholarly literature. In this case study environment the results affirmatively demonstrated the business benefits of using a cloud-based architecture to enable the agile design and delivery of a diverse range of multi-enterprise business processes. This two-year study provided a unique opportunity to explore the phenomenon of service-oriented design from the perspective of a practitioner researcher with intimate knowledge of the case study environment and reputation for the innovative use of information and communications technologies to achieve business value and results.

The exploration of the study's findings and conclusions begins with discussion of how the convergence of service-orientation and cloud computing can enable an organizational shift from a technology-centric focus towards leveraging technology to meet business needs. The discussion transitions to how the cloud-based service-oriented infrastructure was designed as a platform to leverage business services to create multi-enterprise business processes in combinations that form service systems and networks. Using a musical metaphor, the cloud integration platform is presented as a three-tiered architecture (micro, meso, and macro) by which business process instrumentation, orchestration, and choreography is conducted by the enterprise. This study represents the first known instantiation of a cloud-based service-oriented infrastructure supportive of a holistic approach to business process management to enable inter-firm collaboration. As such, this case study offers a glimpse into the future of cloud-based service-oriented design in the enterprise, in particular as an agile approach to integrate internal business processes with the growing number and types of cloud-based services. Continuing with a musical analogy the discussion concludes with the introduction of the notion of business process improvisation. The study results suggest that the range of capabilities and speed of deployment delivered by the cloud integration platform enables a type of business process improvisation through the discovery of new business services and the experimentation of different types and combinations of services, sometimes leading to the design of differentiated and innovative business processes.

5.2.1 Business Perspective of "the Cloud" and Service-Orientation

Service-oriented architecture and cloud computing are arguably two of the most hyped and least understood concepts in information systems over the last decade. The majority of the scholarly literature on the topics of service-oriented architecture and cloud computing has mainly focused on technical aspects with minimal evidence of actual business benefits. The available literature on service-oriented architecture deployments in practice is most often presented in the context of multi-national enterprises seeking to rationalize their complex and disparate portfolio of internal applications and systems. There is no scholarly research or practitioner-based literature available on the adoption of service-oriented architecture in small and medium-sized enterprises. Similarly, much of the literature on the topic of cloud computing is focused on technical aspects and the commonly accepted definitions of cloud computing are exclusively technical in their description. Researchers and practitioners often cite enhanced agility as the primary benefit of adopting service-oriented architecture and cloud computing. In both cases the emphasis on agility is predominantly technology focused.

In service-oriented architecture, agility is most often associated with the effective design and development of software. In cloud computing, agility is typically associated with the rapid provisioning of infrastructure and the shift of the technology investment from a capital outlay to an operating expense.

Contrary to the focus of the majority of academic literature and practitioner sources, the true intent of service-oriented architecture as a design philosophy and cloud computing as a delivery model is to abstract the enterprise user from the technical details of the underling infrastructure. The goal of services computing is to achieve greater alignment of technology and business services, thereby leading to higher levels of flexibility and agility in response changing business requirements. The main contribution from this study suggests that when technology is delivered "as-a-service" the enterprise can become more focused, capable and effective at leveraging technology to achieve business objectives. In this study, the cloud-based service-oriented infrastructure enabled the enterprise to focus on the ongoing design, deployment, and governance of flexible and agile business processes to integrate the firm's capabilities with business partners. Moreover, this study provided a business perspective of the notions of enterprise flexibility and agility which are not well-defined concepts in the literature and lack empirical data in practice. In this study, enterprise agility is defined as the organizational capability to dynamically adapt business processes in response to market changes and distinguishes flexibility from agility, where flexibility is the capability to adapt to known changes and agility is the capability to adapt to known and unknown changes in the environment.

The motivation for the study and design of a cloud-based service-oriented infrastructure is deeply rooted in a philosophical perspective that views service-oriented technologies as a "means to an end" to support business objectives. As this study explored the transition of a medium-sized manufacturing enterprise towards a service-oriented paradigm, the research and design of the IT artifact was also influenced by more practical concerns. By delivering a service-oriented infrastructure as-a-service, small and medium-sized enterprises avoid the significant ($1M+) purchase cost for an enterprise integration solution. Moreover, the cloud integration platform was designed to deploy functionality incrementally as needed, thereby enabling the realization of business benefits sooner. The research pursued an "outside-in" service-oriented architecture adoption pattern that focused on the integration of business partner processes in contrast to the typical internally focused service-oriented architecture deployments most often described in the literature and practice. The cloud integration platform designed in this study, leveraging an outside-in SOA pattern, delivered a unified architecture to integrate the internal business processes of the enterprise with a network of business partners and cloud providers, which is advantageous to medium-sized enterprises.

This study offers a unique perspective of service-oriented architecture, cloud computing, and their synergies not present in the scholarly literature or practitioner-based sources. This study moves beyond the technical considerations of flexible software design in service-oriented architecture and the rapid provisioning of cloud infrastructure. As demonstrated in this study, the convergence of service-oriented architecture and cloud computing results in a new type of cloud platform to dynamically establish, operate, and dissolve partnerships in support of a business strategy. The cloud-based service-oriented architecture designed in this study enabled Mohawk to focus on the design of business services, business processes, and business models based on partnerships. In this context, service-oriented architecture is a design philosophy that leverages business services delivered on-demand to integrate the internal capabilities of the enterprise with those of a network of business partners and cloud providers. This perspective of SOA and Cloud convergence represents a shift from an intra-architecture to inter-enterprise architecture with applicability to medium-sized enterprise rather than large enterprises only, and from a predominantly technical endeavor towards a holistic approach to business process management across the boundaries of the enterprise. In this study, the convergence of SOA and Cloud provided the foundation for an emerging business technology platform and intermediation model to enable a business strategy that leverages partnerships and collaboration for the purposes of value creation.

5.2.2 Cloud-Based Service-Oriented Business Architecture

The intent of this section of the discussion is to unify several of the concepts introduced and demonstrated in this research as a cloud-based service-oriented architecture supportive of a holistic approach to business process management, thus enabling the transition towards a service-oriented enterprise. The discussion begins with a review of the various perspectives of the cloud integration platform described in this study, and attempts to unify them into a cloud-based service-oriented architecture. The discussion continues with a description of how the cloud integration platform enabled a comprehensive approach to business process management starting with business services to compose business processes to collections of business processes in service value networks. As this service-oriented approach to business process design and management involved the selection, composition, and orchestration of business services, music provides a useful and interesting metaphor to describe the cloud-based service-oriented business architecture.

In this thesis, the primary IT artifact designed in this study has been described as a Service-Oriented Cloud Computing Infrastructure (SOCCI), as an integration Platform-as-a-Service (iPaaS), and as Cloud Services Brokerage (CSB). In part, these various descriptions reflect the emergent nature of the topic under study and also the perspectives of the constituencies influencing the direction of this phenomenon. A contribution emerging from this study is an understanding of the relationship among these constructs and attempt to unify them in the conceptualization of cloud-based service-oriented business architecture. As described in more detail below, the cloud-based service-oriented business architecture is represented by a service-oriented infrastructure-as-a-service, delivering integration applications and as a platform-as-a-service, supported with technical expertise using a cloud services brokerage model. Collectively, these capabilities are delivered "as-a-service" to provide a platform to enable the enterprise to efficiently design and deploy a range of flexible business processes to integrate a network of external business partners.

The foundational layer of the cloud-based service-oriented business architecture consists of the service-oriented infrastructure. The Open Group (2011) defines this layer as a service-oriented cloud computing infrastructure that delivers the services-based communications by leveraging the essential characteristics of cloud computing (i.e. utility-based, on-demand, elasticity). The cloud-based service-oriented infrastructure enables loose-coupling across technology and geographically disparate applications and hardware. Leveraging this cloud-based service-oriented infrastructure, solutions providers can offer a comprehensive suite of applications and enterprise integration capabilities to the enterprise "as-a-service". This represents an integration Platform-as-a-Service (iPaaS) as the means to design, execute and manage business processes to integrate the core capabilities of the enterprise with those of business partners and cloud providers. Cloud Services Brokerage has emerged as a model that offers services (e.g. people, methodologies, and technologies) to the enterprise to assist with business integration projects that are cloud-centric. As illustrated in figure 10, the primary artifact designed and implemented in this study is a cloud-based service-oriented architecture consisting of a service-oriented cloud computing infrastructure, an integration platform-as-a-service, and cloud services brokerage model, upon which the enterprise users conduct the ongoing design of multi-enterprise business processes.

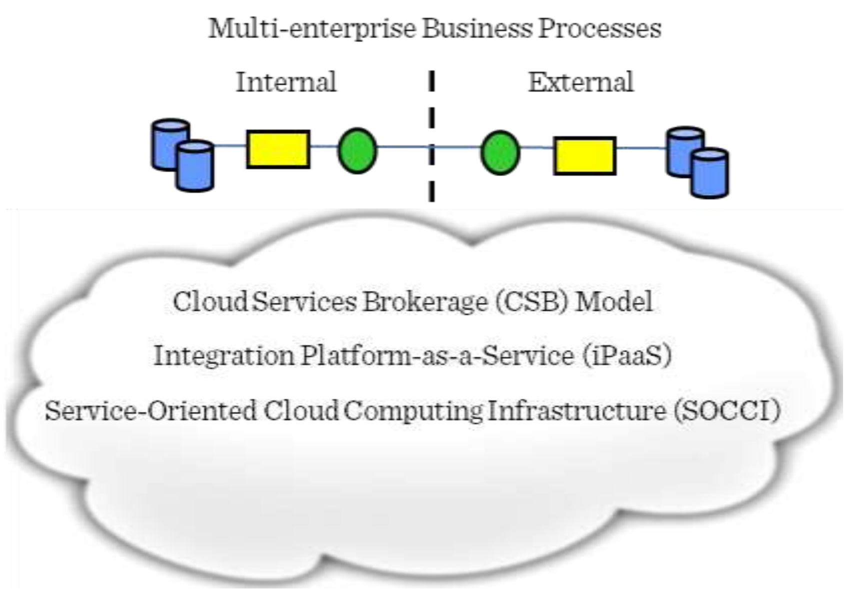

Figure 10. Structure of the Cloud-Based Service-Oriented Architecture

As described, this study represents the first known instantiation of a cloud-based service oriented architecture supportive of a wide range and combination of traditional business-to business and emerging cloud-based integration requirements. As such, the results from the study provide meaningful insights to influence the direction of this emerging phenomenon. In 2009, Gartner introduced the notion of cloud brokerage and described it as the "single largest growth opportunity in cloud computing" (Plummer, 2009). Since then a number of consulting firms and solutions providers have begun to offer their interpretations of cloud brokerage. The majority of these perspectives describe cloud brokerage as services to assist the enterprise with the selection and negotiation of the most appropriate cloud services to meet their business needs. Other perspectives of cloud brokerage envision a set of tools and services to enable automated "switching" between cloud infrastructure providers to meet increased computing demand (e.g. cloud bursting) or to optimize cost and reliability. Aside from this research, no perspectives of cloud brokerage have emerged that specifically focus on business process interoperability between the enterprise, business partners, and cloud service providers.

Since the inception of this research study, a number of IT vendors have entered the market with integration Platform-as-a-Service (iPaaS) solutions. As an emergent market, there is currently fragmentation in the types of cloud-based integration service providers. Some vendors focus on the integration of SaaS applications and others on web-service integration. More recently, a relative few are moving towards delivering a platform to address different types of business integration scenarios. However, these solutions have not fully embraced the principles of service-oriented architecture and cloud computing that provide the basis for business process flexibility and agility. Gartner has described the results from this study "as novel at several levels". Specifically in the "degree of spread between the combinations of on-premise, traditional business-to-business, and cloud-based services, whereas most projects tend to strongly emphasize one over the other." This perspective corroborates the novelty of the artifact designed in the study and also informs this research question that the cloud integration platform designed and demonstrated in this study enables higher levels business process agility by delivering a range of business process integration capabilities.

As discussed, the cloud integration platform provided the technical foundation for Mohawk to effectively design business processes to enable inter-organizational collaboration and a business model based on partnerships. By delivering a robust set of integration capabilities and supporting technical services, the cloud integration platform has empowered Mohawk to focus on the design of multi-enterprise business processes in support of business goals. The remainder of this discussion elaborates on the business component of the cloud-based service-oriented architecture and how it has enabled Mohawk to pursue a comprehensive approach to inter-enterprise business process management.

Figure 11 below depicts the conceptual framework for the business layer of the cloud-based service-oriented architecture that emerged from the study. The service-oriented approach to business process design leverages a repository of business services as the building blocks to orchestrate business processes and choreograph them into combinations to achieve a set of business objectives. The business layer of the cloud-based service-oriented architecture is represented as a hierarchy of three sub-architectures: micro-architecture, meso-architecture, and macro-architecture. In this study, business services are designed and discovered at the micro-level, business processes are orchestrated at the meso-level, and service systems and networks are choreographed at the macro-level.

The terms business process orchestration and orchestration are not well-defined in practice and the scholarly literature. Most often the terms choreography and orchestration are used in the context of web services; where web service orchestration is the execution of a specific business process and web service choreography relates to interactions among a collection of web services (Peltz, 2003). Orchestration is the way that business processes are constructed through the integration or data flow among two business services (Montealegre et al., 2008). Choreography involves the strategies and directives to define the interactions among business processes for business purposes (Montealegre et al., 2008). Thus, for the purposes of this study, business process orchestration is defined as the coordination of business services to establish an end-to-end business process to achieve a business function. Business process choreography is defined as the coordination of a collection of end-to-end business processes resulting in the formation of service systems and networks to achieve an overarching business objective. In summary, business services representing a discrete unit of business functionality exposed using standardized interfaces provide the instrumentation to orchestrate business processes to achieve a particular function which can be choreographed into combinations to form service systems and networks achieve an overall business strategy. This represents the emerging architecture of the service-oriented enterprise, conceptualized as the hierarchy of a micro-architecture (business services), meso-architecture (business processes) and macro-architecture (business networks), illustrated below in figure 11.

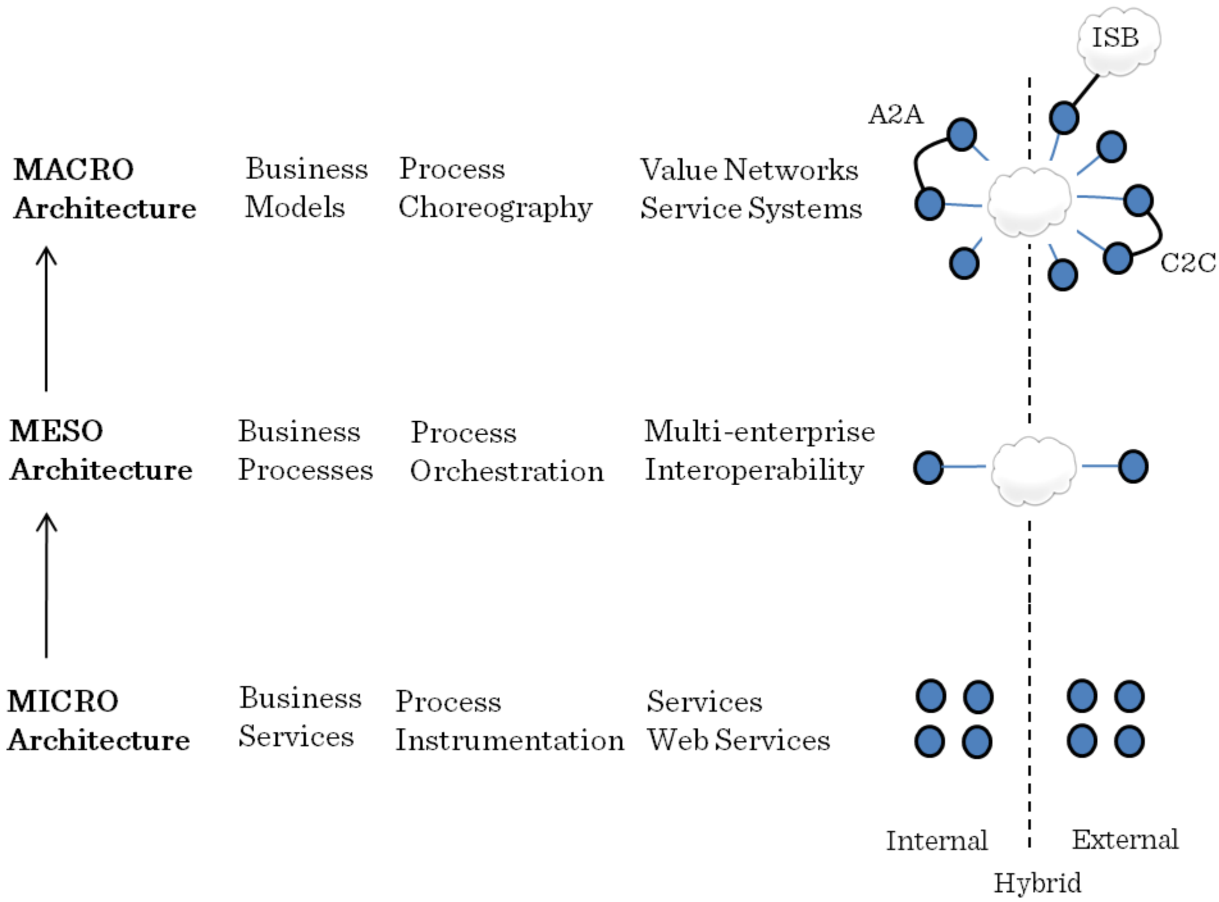

Figure 11. Business Layer of the Cloud-Based Service-Oriented Architecture

Micro-Architecture – The micro-architecture represents the foundation of the cloud-based service-oriented architecture. At this level, business services defined as sharable, reusable components of discrete business functionality are the fundamental component required for the composition of business processes. Business services may be designed by the enterprise or provided by business partners and cloud service providers. In this study, a total of 46 business services were developed or made available for consumption in business processes. At this level of the cloud-based architecture the internal and external business services are accessible through a service registry residing in the cloud environment and governed by the cloud service broker. At the micro-architecture, technical services are analogous to musical instruments producing different types of sounds and the repository of business services are analogous to a catalog of songs available for orchestration and choreography in a musical performance.

Meso-Architecture – The term meso-architecture has not been previously referenced in the scholarly literature in the context of information systems. The prefix meso has the meaning of being in the "middle" or "intermediate." The notion of a meso-architecture is introduced in this research as the architectural level in which intermediation occurs between disparate business services. Orchestration, in a musical context is the composition and arrangement of a sequence of steps to perform a piece of music. Similarly, business process orchestration is the composition of business services in a sequence of activities to achieve a particular business function. At the meso-architecture level, the combined capabilities of the cloud integration platform and the cloud services broker are leveraged to provide intermediation services (e.g. translation, communications, monitoring, and security) to design, deploy and manage multi-enterprise business processes. In this study, a total of 56 multi-enterprise business processes were designed and orchestrated at the meso-architecture level.

Macro-Architecture – An overall business strategy is realized at the macro-architecture of the cloud-based service-oriented architecture. At this level, unique combinations of multi-enterprise business processes (i.e. A2A, B2B, C2P, and C2C) are choreographed to achieve an overarching business strategy. In music terms, this is analogous to a conductor who assigns combinations of musical instruments and choreographs them in a collection of compositions (songs) in a musical performance. The cloud integration platform enabled the orchestration of multi-enterprise business processes to integrate the capabilities of the enterprise with those of business partners and cloud service providers. The choreography of combinations of multi-enterprise business processes resulted in the formation of service systems and networks designed to achieve a business objective. In this study, collections of business processes were orchestrated in unique combinations and patterns to enhance the efficiency of the supply chain, to more effectively manage financial and accounting processes, and to create new business models for revenue generation. The capability to dynamically integrate the internal capabilities of the enterprise with those of a network of external business partners represents the realization of a service-oriented enterprise.

In summary, the primary artifact designed in this study leveraged the principles of service-oriented architecture and cloud computing to develop a platform for the dynamic creation of business processes, service systems and value networks. The delivery of infrastructure and technologies as-a-service, combined with intermediation services of a cloud broker, enabled this medium-sized enterprise to focus on the exploitation of these capabilities for business purposes. The resulting cloud-based service-oriented architecture is described in terms of a three-tiered hierarchy consisting of micro, meso, and macro sub-architectures, which are associated to business process instrumentation, orchestration and choreography. Business services provide the instrumentation (micro-architecture) for the orchestration of business processes (meso-architecture) that are choreographed into combinations to achieve higher-level business goals and objectives (macro-architecture).

5.2.3 Business Process Agility: Transactional to Improvisational

This case study demonstrated how a cloud integration platform enabled a medium-sized enterprise to realize a business strategy that leverages the capabilities of business partners and cloud providers. The results suggest the cloud integration platform enabled enhanced levels of business process agility in the case study setting through the adoption of a service-oriented approach to the design of multi-enterprise business processes. This section of the discussion seeks to emphasize the business perspective of this enabling technology and to further elaborate upon the business layer of the cloud-based service-oriented architecture. The remainder of this discussion explores the different types of multi-enterprise business process designs pursued during the study. Of the 95 service interactions deployed in the study three types or classifications of multi-enterprise business processes emerged, those that are transactional, differentiated or innovative in their intent and business outcome. As importantly, the enhanced level of business process agility afforded by the cloud integration platform has enabled a new type of business process design that embraces experimentation. As the enterprise discovers new business services and reuses business services, they can be choreographed into unique combinations, sequences, and patterns in an improvisational way. In some instances, this type of discovery and experimentation may result in a differentiated or innovative capability when applied to a particular business context. The notion of business process improvisation is introduced and explored in the remainder of this section. As with the use of the terms instrumentation, orchestration, and choreography to help describe service-oriented business process design, musical composition and performance provides a lens to introduce and inform the notion of business process improvisation observed in this study.

Two perspectives on the topic of business process improvisation are incorporated into the discussion. The sources of inspiration come from distinctly different backgrounds and offer contrarian views on the notion of improvisation. The first is the late Dr. Michael Hammer who is widely recognized as a thought leader in the discipline of business process design and management. This researcher participated in a series of courses during the period of 2004-2007 with Dr. Hammer as part of a certification in Business Process Mastery. The second source of inspiration is the contemporary rock band Phish. This researcher has been an avid follower of this "jamband" known for its musical improvisation and the blending of musical genres. The juxtaposition of the topics of service-oriented design for business performance and the fusion of different types of genres in a musical performance offer interesting insight into how improvisation in business process design is enabled by the cloud platform designed in this study.

The discussion starts with a definition of the term improvisation. Improvisation has been broadly defined as the creative and spontaneous process of trying to achieve an objective in a new way (Vera and Crossan, 2005). In organizational theory, improvisation occurs when the design and execution of novel activities converge (Baker et al., 2003). In musical theory, improvisation has been described as both a sequential structure of sounds and the creative use of musical material drawn from a musical tradition (Alperson, 1984). In the context of this study, a Google Scholar search of the term "business process improvisation" generates no results or references in the scholarly literature. Thus, for the purposes of this discussion and leveraging the definitions above, business process improvisation is defined as the creative and spontaneous process involving both the design and execution of a sequence of activities using available capabilities to achieve business objectives in new ways.

Dr. Michael Hammer was well known as an evangelist for business process re-engineering and advocate for business process discipline, repeatability and clarity of action in order to improve business performance. In his lectures and writings, Dr. Hammer expressed disdain for improvisation in the context of business process design and execution, suggesting it was a symptom of dysfunction in the organization. He argued that the heroics of improvisation should be eliminated and replaced with specific designs for business processes so that their performance was not determined by improvisation or luck. However, in the last chapter of his final book ("*The Agenda*") before his death in 2008, Dr. Hammer foresaw a new wave of business process designs that would span the boundaries of the enterprise and would result in "unprecedented inter-enterprise collaboration" and "extraordinary benefits" (Hammer, 2001). To be sure, this new wave of business process designs would require well-structured actions to be effective, but it's likely that Dr. Hammer had not fully anticipated the potential role of improvisation to leverage cloud platforms and the growing number of cloud-based services available on-demand for composition in enterprise business processes. In part, this research seeks to build upon the seminal works of Dr. Hammer and suggest how it may have evolved in the context of a service-oriented enterprise leveraging an emerging cloud-based business integration platforms and an ecosystem of on-demand business services available for composition in enterprise business processes.

As suggested, musical composition and performance as exemplified by the jamband Phish serves as a vehicle to explore the role of improvisation in service-oriented business process design and execution. Originating in Vermont in the early 1980's the band Phish has been performing for thirty years and is well known for its musical improvisation and exploration of music across genres. Phish leverages a catalog of over 600 original songs which are played in different sequences, extended, interwoven within songs, and creatively transitioned into other songs, making each of their live performances unique. The band has not had mainstream commercial success but has a dedicated and loyal fan base that attends their concerts and distributes recordings of many hundreds of live performances over the last three decades. To establish a connection to this research and to provide insight into the phenomenon of improvisation in the context of service-oriented business process design and execution, the salient characteristics of the improvisational paradigm central to Phish are presented from the perspectives of several musical scholars and my own experiences.

The members of Phish describe their commitment to improvisation as a guiding philosophy and desire to continually create new music while embracing both its successes and failures (Blau, 2007). Moreover, they believe that their acceptance of risk and uncertainty (as well as their audience) when performing is essential, knowing at times it may or may not lead to the discovery of something new, momentous, or even memorable. For Phish, improvisation mostly flows from what has already been done where perceptions of newness result from the subtle nuances in how songs are spontaneously performed (i.e. duration, phrasing, melody, and harmony) in a particular context. Phish relies upon an extensive musical tradition and their broad range of musical capabilities, skills and preparation to maximize the possibilities for experimentation in their live performances (Yeager, 2011). The notion of improvisation is a complex phenomenon which has been superficially addressed in this discussion. However, several interesting associations emerge from this researcher's reflection on the study results, the scholarly literature on service-oriented design, and the music of Phish.

At the highest level, the phenomenon of Phish and the service-oriented enterprise are both driven by a philosophy that embraces the notion of change through the virtues of flexibility and agility. Both phenomena leverage a fundamental unit of functionality, a catalog of songs or a repository of services that are developed or borrowed as the basis for offering value propositions. The architecture or structures that enable flexibility are also similar, both leveraging instrumentation (songs or services), that are orchestrated into sequences, patterns and interactions (concerts or business processes), and ultimately choreographed to pursue an overarching objective (i.e. musical evolution or business strategy). In both cases, Phish in the creation of music and Mohawk in the creation of multi-enterprise business processes, flexibility and agility flow from the breadth of a repository of songs or business services and capabilities to arrange and re-arrange them into unique combinations. Phish leverages a catalog of over 600 songs, thirty years of experience as a band, and the continual introduction of instrumentation. Mohawk relies upon a repository of 50 business services, a management structure accepting of change, and set of technologies and capabilities that are offered as a service and continually evolving.

The discussion suggests some commonalities in how music and business processes can be composed and delivered. As importantly, the improvisational paradigm central to Phish may provide insight into how future service-oriented systems and processes are designed. Phish embraces exploration and discovery in the creation and performance of their music. As presented in the literature review, several scholars have argued for a service-oriented design paradigm that is open to the possibilities of innovation by embracing indeterminacy in design problems and outcomes (Vargo and Lusch, 2006; Chen and Vargo, 2010). Other researchers suggest that improvisational performance may help goods-dominant firms to integrate services in their core market (Neu and Brown, 2005). The music of Phish is contextualized in time and space as the band creates and adapts their music based on the particular venue and interactions with the live audience. This represents a shift from a product-orientation of distributing music on media towards a service-orientation where the value-proposition is offered in the context of the live performance. Scholars have argued for a service-oriented design paradigm that embraces an environment to include the customer as an active participant and co-creator in the design process. This perspective emphasizes "value-in-context" rather than "value-in-exchange" which is predominant in traditional and product-centric information system design approaches (Chen and Vargo, 2010).

It is suggested that Phish provides a lens into how organizations can enable a philosophy of change by leveraging a robust platform of capabilities, by embracing the indeterminacy of design outcomes and with it acceptance of risk, and through the co-creation of innovative value propositions with its customers. Moreover, in the context of structure and discipline in business process design and execution as advocated by Dr. Hammer, there seems to be a complementary role for business process improvisation in the enterprise. A number of scholars have advocated a service-oriented design approach that embraces an environment of collaboration with customers to participate in the co-creation of information systems and business processes to offer value-propositions that are situational in a unique context. The business process agility afforded by the cloud-based service-oriented architecture, in terms of a broad range of capabilities and the speed of deployment, has provided Mohawk with a platform to discover new types and combinations of business services and processes. A principle guiding the design of the cloud-based service-oriented architecture was to enable any-to-any connections of services without regard to the underlying technology or location. By design, the cloud platform embraces the indeterminacy of outcomes by accommodating business process flexibility (known requirements) and agility (unknown requirements). Moreover, because different types and combinations of business processes can be designed at relatively low effort, cost and therefore risk, an environment is created that encourages discovery, experimentation and customized designs in collaboration with business partners.

Many of the multi-enterprise business processes designed in this study demonstrated novel types and combinations of service interactions, particularly those combining traditional and cloud integration. Several of these use case scenarios may be described as business process improvisation in terms of their creativity and spontaneity of their design and/or execution. They pursued variations or nuances of existing service interactions in the discovery of a new capability rather than in response to an explicit business requirement. The first example is the re-use of a web-service that provides real-time visibility into Mohawk's inventory levels and pricing. This price and availability web-service was used in several business processes designed to integrate Mohawk's internal systems with cloud-based eCommerce web-sites. During the study, the idea was conceived to integrate this capability directly with customers systems. A customer was identified to co-design an inter-enterprise business process to enable their purchasing agents to automatically check Mohawk inventory and pricing for a product from within their systems. This experiment proved to be successful and mutually beneficial as it streamlined the workflow of the customer and generated increased demand for Mohawk paper. From the perspective of service-oriented design, this use case scenario demonstrates how the cloud platform encourages discovery through variations in existing business services and processes and the capability to co-create designs in a unique business context. Arguably, the conception and demonstration of this capability was improvisational as it has become a source of differentiation within the industry. As this capability becomes more widely known and replicated, the business process will likely follow a trajectory of design from improvisational to differentiated and ultimately to transactional when adopted and diffused throughout the industry.

Several of the service interactions designed and implemented in the study are examples of business process improvisation in their design and execution. They are improvisational in design as they were pursued through experimentation by varying the sequence and patterns of existing service interactions. They are considered improvisational in their execution as they were designed to respond in a particular way during run-time based on situational or contextual factors. As these examples employ cloud services their action has been described as arbitrage in the context of cloud brokerage (Plummer and Kenny, 2009). Arbitrage is an emerging concept where the cloud broker intermediates the selection and use of the most “appropriate or opportunistic” cloud service for a particular situation or context (Lui et al., 2011; Sundeep, 2011). According to Gartner, the use-cases from this study described below are the first known instances of cloud service arbitrage applied in practice.

The first example of cloud service arbitrage leveraged a previously designed and deployed service interaction that invoked a cloud service at StrikeIron to update Mohawk's systems on a daily basis with exchange rates for international currency. With minimal development time and cost, the cloud service was modified to determine the exchange rate for the country of destination at the time the order was shipped. If the exchange rate was favorable, it was reflected in the customer invoice, thereby decreasing the cost of the sale. A second example of arbitrage and improvisation in business process execution relates to the calculation of freight rates for product shipment by logistics partners. A service interaction was designed to invoke cloud services from UPS, FedEx, and MercuryGate at the at the point of shipment in Mohawk's eCommerce web-sties and enterprise system. The cloud broker returns freight rates from the various shipment providers and suggests (arbitrates) the most favorable rate and service level for the product and destination, in the unique context of that customer order. Arguably, these business processes were improvisational in their conception, design, and execution, facilitated by the business process agility of the cloud integration platform.

The results from the study demonstrated a range of multi-enterprise business processes, many of which were orchestrated and choreographed in unique combinations to establish service systems and networks designed to increase operational efficiency or generate additional revenue. Many of these multi-enterprise business processes were designed to address known requirements and pursued transactional efficiency and the elimination of non-value-added work as advocated by Dr. Hammer. More importantly, the cloud integration platform has enabled a new and complementary approach to service-oriented business process design and execution. It is observed that the enhanced levels of business process agility delivered by the cloud platform facilities and encourages experimentation in business process design and spontaneity in business process execution. In the absence of a conceptual framework in a business context, a musical analogy is offered as a perspective of improvisation in business process design and execution. The results from this case study suggest that improvisation in business process design and execution is enabled by a culture that embraces change, with acceptance of some level of risk, and leverages a broad range of technical capabilities and a repository of services as the basis for the ongoing creation and re-creation of business processes. In the scenarios offered as improvisational in this study, several patterns or themes emerged. In each of the cases, the designs were based on previous instantiations, they were pursued in the discovery of new ideas rather than from a specific business requirement, the design time and cost was minimal, and they used "fine-grained" cloud services for nearly real-time composition and orchestration in the design of multi-enterprise business processes. The implications of incorporating the proliferating number and types of cloud services in enterprise systems and business processes, enabled by the cloud integration platform and cloud brokerage model, are discussed in more detail the final section of this thesis.

The study results suggest the existence of three types of multi-enterprise business processes in the case study environment (e.g. transactional, differentiated, or innovative). Many of the service interactions designed in the study automated routine operational tasks and may be categorized as transactional business processes. These service interactions and business process designs had explicit specifications, changed infrequently, and typically processed large amounts of structured data. A second design that emerged from the case study is a differentiated business process. A differentiated business process has characteristics that are specific or unique to the enterprise or to an industry segment. Differentiated business processes had semi-structured specifications and required configurability (i.e. flexibility) in response to known opportunities in the business environment. In this study, differentiated business process designs and outcomes involved the integration of traditional business partners and emerging cloud providers. A third type of secondary design that emerged from the study is the innovative business process. In this study, an innovative business process design was a response to a new or emerging business opportunity or an outcome of business process improvisation. In these scenarios, design specifications and outcomes were not well known, the design was conducted in hours and their execution is in near real-time, and they involved the composition of fine-grained cloud services orchestrated into synchronous (real-time) multi-enterprise business processes.

Using the cloud-based service-oriented architecture schematic previously presented in this discussion, it is instructive to overlay these three secondary design types across the micro, meso, and macro layers of the business architecture. In figure 12, the relative percentage of business services and processes designed in the study are depicted by the type of secondary design. As described, most of the multi-enterprise business processes pursued in the study were transactional, exhibiting low complexity, rate of change, and commoditization of their business value. This type of transactional design is most prominent in the micro-level of the cloud business architecture as business services, representing units of functionality, are typically designed to specifications and generalized to enable reuse across use cases. At the meso-architecture level, where business services are orchestrated together to establish multi-enterprise business processes, differentiated and innovative secondary design types become more common, representing approximately one-third of the use cases in this study. At the macro-level of the architecture, where unique combinations of multi-enterprise business processes are choreographed together to establish, configure and dissolve service systems and networks, the relative percentage of differentiated and innovative secondary designs increase. At this level, business process differentiation and innovation results from the choreography of unique combinations of traditional business processes with cloud services.

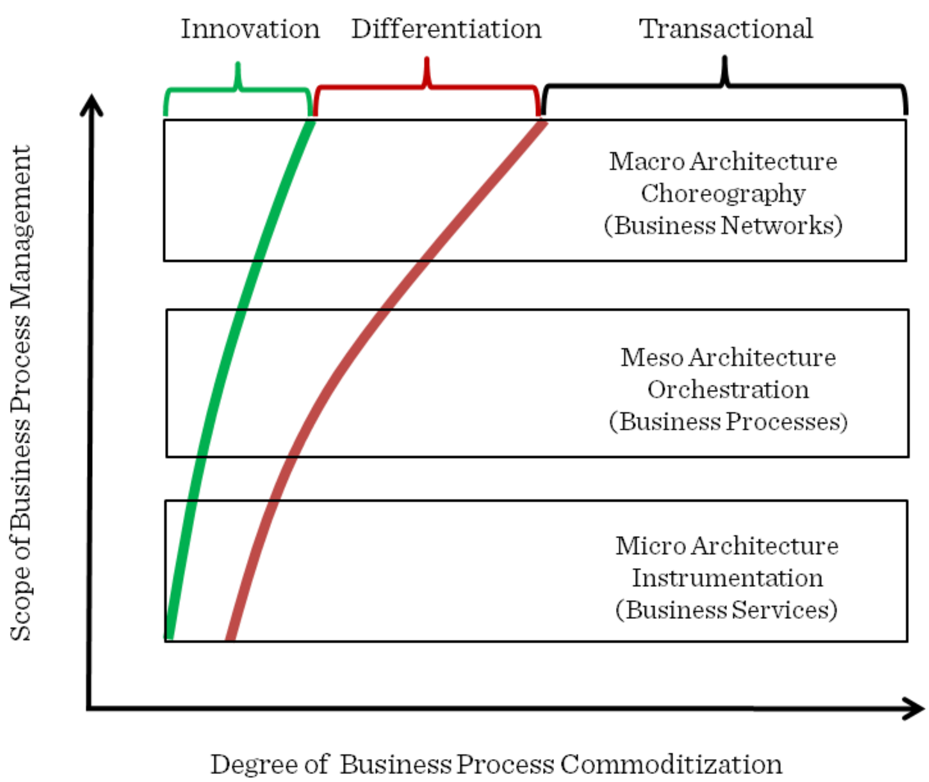

Figure 12. Design Types of the Cloud-Based Service-Oriented Architecture

This perspective suggests that when taking a holistic view of business process management, starting from business services to business processes to service systems and networks, the business process agility enabled by the cloud platform and brokerage model supports the co-existence of different secondary design types. As prescribed by Dr. Hammer, a substantial number of the business processes designed in the study had well-defined specifications and pursued transactional efficiencies and elimination of non-value-added work. However, as business processes extend across the boundaries of the enterprise and become choreographed into unique combinations, the secondary design activities can become more differentiated and innovative. Moreover, as business opportunities become more specialized, contextual, and situational, secondary designs activities can exhibit characteristics of improvisation enabled by a cloud platform conducive of experimentation and configurability at runtime. These results and findings suggest the various types of secondary designs ranging from transactional, to differentiated, to innovative are complementary and each should be applied as appropriate in the context of the business requirements and opportunities.

By definition, the objective of a service-oriented enterprise is to leverage a flexible and agile architecture to effectively and continually respond to the changing demands of the market. For Mohawk, the transition towards a service-oriented enterprise represents a shift from a traditional business model and associated information systems and business processes that focused on operational and transactional efficiency. In reality, operational efficiency in the conduct of inter-firm partnerships and collaboration is a desired and necessary capability. However, the full transition towards a service-oriented enterprise requires the capability to improvise while being simultaneously efficient (Konsynski and Tiwana, 2004). The pursuit of transactional efficiency should not decrease the enterprise agility necessary to design and deploy differentiated and innovative multi-enterprise business processes. Thus, in today's networked service-based economy with dynamic configurations of business partnerships with changing customer demands, the enterprise must simultaneously pursue and balance transactional efficiency with flexibility, agility and arguably improvisation in their business processes. A significant finding emerging from the study suggests that the cloud integration platform enabled the necessary business process agility to efficiently design and deploy a range of transactional, differentiated, and innovative multi-enterprise business processes. More importantly, the business process agility enabled by the cloud platform provides the foundation for the transition towards a service-oriented enterprise and pursuit of partner integrations and collaboration as required in each unique business relationship.

5.3 Research Study Recommendations and Implications

This final section of the thesis provides a synthesis of the key research findings, conclusions and discussion points presented in this chapter (section 5.3.1). This integration of preceding conclusions and perspectives provides the basis for the presentation of recommendations primarily targeted to information technology practitioners considering cloud integration or more effective business partner integration and interoperability (section 5.3.2). In the last section of the thesis, this researcher presents his final thoughts on how the proliferation of cloud-based services and the emergence of cloud integration platforms will influence how enterprise systems are used and why this study provides a foundation for future scholarly research (section 5.3.3).

5.3.1 Research Study Conclusions and Discussion Summary

This case study followed the transition of a medium-sized manufacturing enterprise over a two-year period towards a service-oriented enterprise. A service-oriented enterprise is an emerging architecture of the enterprise that leverages the paradigm of services computing to integrate the internal capabilities and competencies of the enterprise with a network of business partners to offer its customers with value-added products and services. The study employed design science research to pursue two interrelated design activities, the primary design of a novel cloud integration platform upon which the enterprise conducted secondary designs of a wide-range of business processes. The primary and secondary design activities leveraged the converged benefits of a service-oriented architecture and cloud computing to enable higher levels of business process agility in the case study environment. In this study, business process agility is defined as the capability of the enterprise to dynamically modify and reconfigure their business processes and is operationalized as the range of capabilities and speed of deployment. The cloud integration platform designed in the study leveraged a repository of 46 business services to orchestrate 95 service interactions that integrated the business processes of the enterprise with those of a network of business partners and cloud providers. The cloud integration platform provided a unified architecture to seamlessly integrate on-premise, business partner, and cloud applications, services and data to address a wide-range of business requirements. Most of these multi-enterprise business processes delivered transactional efficiencies, while others when combined in unique combinations, patterns, and sequences delivered differentiated and innovative business process designs and dynamic configurations of service systems and value networks.

Figure 13 below represents the architecture of the service-oriented enterprise conceived, designed and demonstrated in this study. This illustration attempts to summarize the key elements of the IT artifact developed and implemented in this study and the design process leading to the artifacts creation and exploitation to address the business problem presented in this thesis. The illustration also seeks to integrate the conclusions that emerged from the study and provides the basis for the presentation of recommendations to practitioners and future scholarly research.

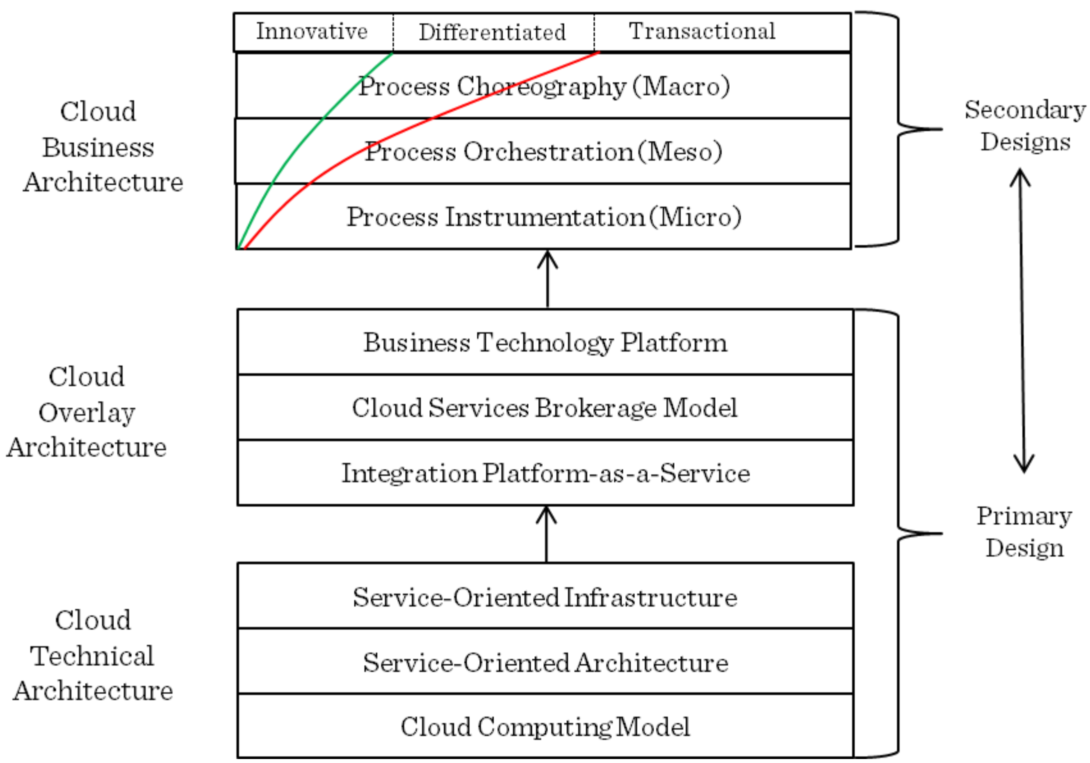

Figure 13. Cloud-Based Architecture of the Service-Oriented Enterprise

The results and findings from this study suggest that the service-oriented enterprise can be represented in a hierarchy of cloud-based architecture layers. One that is built upon on a cloud technical architecture, abstracted through a cloud overlay architecture, leading to a cloud business architecture layer. At the cloud technical architecture layer, the philosophy of service-oriented architecture and principles of cloud computing are leveraged to deliver a service-oriented infrastructure as-a-service. This cloud technical architecture provides the foundation for business process agility where cloud computing enables the integration of disparate hardware and service-oriented architecture enables interoperability of diverse systems, applications, and data.

A key finding emerging from the study is the notion of the cloud overlay architecture. The cloud overlay architecture exposes business capabilities as services and therefore abstracts enterprise users from the complexities of the underlying cloud technical architecture. This perspective expands the contemporary notion of cloud computing beyond an operational layer to host applications towards the perspective of "the Cloud" as a business platform to integrate applications and business processes, the fundamental thesis of this research. In this study, the cloud overlay architecture is represented by a set of integration capabilities delivered as an integration Platform-as-a-Service combined with the complementary intermediation services of a cloud broker.

The cloud business architecture leverages the cloud integration platform to conduct the ongoing integration of on-premise and cloud-based systems, applications, services, and data in response to changing business requirements. At this business architecture layer, the notion of three interrelated sub-architectures is introduced upon which a holistic approach to inter-enterprise business process design and management is pursued by the enterprise at the micro-architecture (services), meso-architecture (multi-enterprise business processes), and macro-architecture (service systems and service networks).

The cloud-based architecture of the enterprise represents the primary IT artifact pursued in this study and embodies several new constructs, models, and methods that are meaningful and actionable to practitioners. This research also provides new insights into the process of service-oriented design. The study findings suggest the existence of primary and secondary design phases, where primary designs result in new cloud platforms upon which enterprise users leverage the technology to perform ongoing secondary designs. In this study, the cloud platform provides the business integration capabilities to empower enterprise users to perform ongoing secondary designs of a wide range of business processes. This research emphasizes the increasing importance of the notion of secondary design as cloud business technology platforms become more widely available to the enterprise. In this study, the cloud integration platform demonstrated enhanced business process agility, by demonstrating an increased range of business integration capabilities and speed of deployment, thereby enabling different types of secondary designs. The secondary design of multi-enterprise business processes demonstrated in this study can be classified as being transactional, differentiated, and innovative depending on the unique context of the business requirement or opportunity. Most of the business process designs resulted in transactional or operational benefits, but became differentiated and innovative when traditional business-to-business and cloud-based services were orchestrated and choreographed.

5.3.2 Research Study Recommendations for Practitioners

This final section of the doctoral thesis presents an overview of recommendations that have emerged from the research. These recommendations are presented with acknowledgement of the inherent weaknesses of a single case study and thus limitations on their applicability to the IT practitioner audience. This case study research examines a single organization with a unique set of challenges, opportunities, capabilities and structure, which therefore limit the generalizability of findings and recommendations. The recommendations are also presented with awareness of the inherent weaknesses and threats to validity associated with the conduct of "insider" or "practitioner" research. As a practitioner researcher with direct influence in the conduct of this research and interpretation of the study's findings, a lack of subjectivity and objectivity may exist and limit the validity and transferability of the recommendations. A number of frameworks and guidelines have been established to help researchers (and readers of the research) to evaluate the quality of the research and the trustworthiness and plausibility of its results and recommendations. Miles and Huberman (1994) established five evaluation criteria which can be generally classified in the terms of objectivity, auditability, credibility, transferability, and application. Perspectives of each these criteria are provided below.

Objectivity. The findings and recommendations presented in this Chapter should be evaluated with an awareness of some degree of impartiality and bias from the perspective of an insider researcher. Miles and Huberman (1994) acknowledge it is completely impossible to eliminate bias from researchers, but ask the question "Is this research overly influenced by bias?" In this study, the use of pre-established data collection procedures and instruments by other project managers helps to reduce the potential for researcher bias in the data collection process. The data collected to answer the research question (enhanced business process agility measured in terms of a range of capabilities and time to deployment) consisted of a small set of quantitative measures such as the number and type of designs, and the time and cost to deploy them. As mentioned, this data was collected with pre-establish instruments and their reliability was cross-checked by project managers and the invoicing records of the cloud broker performing the design. This researcher acknowledges a lack of objectivity and absence of supporting data in the discussion of business benefits resulting from the implementation of the artifacts in the study – as a demonstration of business value was not central to the research question and was not supported by prescribed data collection methods.

The duality of roles inherent in the conduct of insider or practitioner research did have an influence and bias on the scope of the study and its outcomes. The breadth of the study results and outcomes (i.e. number and types of multi-enterprise business processes deployed) were directly influenced by the dual roles of this practitioner research, as design decisions were motivated by business requirements in the case study environment and the scholarly desire to explore new types of business integration use case scenarios. This influence was exerted by establishing design priorities and approving the allocation of resources to accomplish these designs. The cloud broker, Liaison Technologies, was motivated to be responsive to the design and successful demonstration new types of business integration capabilities, as a means to secure "mind share" in the emerging cloud services brokerage solution space. The dual roles of practitioner and scholar did not create tension in the study, but rather created an environment to pursue a wide range of integration scenarios faster.

<u>Auditability</u>. The auditability or dependability of the study results and conclusions are directly related to the research methods employed. This study employed a design science research methodology prescribed as representative of high quality design science research. This study was conducted in accordance with the six phases of the design science research process, beginning with the problem identification and motivation phase, to the definition of objectives for a solution phase, the design-development-evaluation phase, and the communication phase. The use of pre-existing project planning and technical specification documents provided a consistent approach in the collection of data and simplified the data preparation process. The procedures employed to prepare (organize, codify and transcribe) quantitative data from these instruments were well documented and therefore enhanced the reliability and auditability of the data collected. The data extracted from the project planning and technical specification documents during the design-evaluation-demonstration phase were reviewed for accuracy, consistency, and completeness by project managers and some of the data was cross-checked with invoices detailing the design hours (and cost) and implementation dates. Later in this Chapter, reflection is provided on the quality of the design science research in information systems process model employed in the study, suggesting further guidelines are necessary to enhance the rigor (e.g. audibility and dependability) of the process.

<u>Creditability</u>. The evaluation of creditability or authenticity relates to the "truth value" of the results. Miles and Huberman (1994) outline 13 tactics for testing or confirming findings, all of which address the need to build systematic "safeguards against self-delusion" into the process of analysis. Miles and Huberman ask, "Do the findings of the study make sense and are they credible to the practitioners and members of the research community, and others?" The issue

of credibility is supported by the full-scale demonstration of the artifact (e.g. cloud integration platform and multi-enterprise business process) in the case study environment. Additionally, the credibility of the study and results have been enhanced through the active communication of research intentions progress, and findings throughout the study and the engagement of various practitioner audiences, where the design principles and approaches employed in this study were deemed to be emergent, innovative and highly relevant to practicing professionals. It is acknowledged by this researcher that the IT advisory, consulting, and media firms that published perspectives on this study each have individual bias and motivations for their actions. However, the three IT advisory firms (Gartner, Deloitte, and InfoTrends) and the two trade media recognitions (CIO Magazine and Mid-Market CIO) independently reviewed the study findings and contributions, thereby providing some level of credibility of the relevance and importance to the current state of information systems design. Lastly, the considerable expertise of the doctoral committee who to guided and directed this study provide some level of credibility as to how the research study was conducted and the relevance of the findings and recommendations.

Transferability. The evaluation of the transferability or "fittingness" of the study results and recommendations is probably the most important criteria for external readers of this study. Miles and Huberman (1994) ask, "How far can the findings be generalized?" Single case study research has limited generalizability (Yin, 1984), particularly in this case study environment which has a unique context (medium-sized manufacturing firm), set of challenges (declining market), and organizational culture (agile and innovative). Given the unique circumstances related to this case study environment, the breadth and scope of the study, and in the conduct of insider research, this study is impossible to replicate in another context and setting. This study concurrently pursued the design of two artifacts, the cloud platform represented as new constructs and models, and one-hundred multi-enterprise digital connections represented by emerging service-oriented design methods. Although the study was conducted in an iterative and incremental manner (e.g. series of cloud platform releases and multi-enterprise designs), when considering the study in totality, it can be described as transformative in its intent and outcome. Thus, it is unlikely (and therefore not generalizable) that a non-software firm, not to mention a medium-sized manufacturing enterprise, would initiate and pursue the design and development of a new type of cloud-based platform. It is also unlikely, to a lesser degree, that an enterprise would pursue such a wide-range and number of business integration designs in a relatively short timeframe.

However, there are a number of aspects of the results, findings and recommendations that may be applicable and transferable to other contexts and settings. Particularly when readers of the study are provided with details of the implementation context (Miles and Huberman, 1994) they can invest in "analytical" forms of generalization to evaluate the potential transfer of the research findings to their own context as the design principles that emerged from one context can often be applied as "guidance and direction" when considered in a similar context (Van den Akker, 1999). The outcomes from the design science research process in the form of new constructs (terms and vocabulary), models (relationships among constructs), and methods (how-to-knowledge) have applicability across different context and organizations. Moreover, there may be broader applicability of the use of a cloud integration platform and the cloud services brokerage for specific business integration uses case (e.g. integrate the enterprise with a cloud service provider such as SalesForce.com), rather than the full transition towards a cloud architecture of the service-oriented enterprise.

Application. The fifth criterion suggested by Miles and Huberman to evaluate research results and recommendations is application or usability, asking the questions "What is the pragmatic value of the research, do the findings make sense to others, and are they transferable into action?" (Miles and Huberman, 1994). A strength of design science research generally and this study specifically is the degree of relevance to practice and the domain of information systems. The results, findings and recommendations from the study have been regularly communicated to practitioner-based audiences and have generated a high-level of interest and discussion in the public domain. As discussed, the constructs, models, and methods developed or informed during this study may provide direction and guidance to IT practitioners. The capabilities of the cloud integration platform and value-added services of the cloud broker may be leveraged in an incremental (vs. transformational) manner across a broader set of contexts.

Using the evaluation criteria developed by Miles and Huberman, a perspective is offered on the objectivity, auditability, credibility, transferability, and application of the research results as context for the presentation of recommendations to IT professionals in the following section. As prescribed by design science research (March and Smith, 1995), recommendations for IT professionals are organized and presented below as new constructs (terms and vocabulary), models (relationships among constructs), methods (how-to-knowledge), and instantiations (representation of an abstract concept in an actual instance).

Constructs. A fundamental goal of this research agenda was to provide insight and clarity to key terms used to describe the business benefits of service-orientation in the enterprise. The core premise that motivated and guided this research is the perspective that technology is a "means-to-an-end" to achieve business objectives. The thesis of the study posited that with new and highly capable integration technologies delivered as-a-service, the enterprise and professionals within them are increasingly able to focus on business objectives rather than a predominant focus on managing the supporting technology. The use of a service-oriented design paradigm to compose business processes using technologies delivered as-a-service represents a fundamental shift in the role of the IT professional and how enterprise systems achieve business results. As a consequence, the vocabulary used to describe the use and benefits of service-orientation also shift from a technical focus towards the business capabilities of the enterprise to effectively respond to changing market opportunities. This perspective represents the emergence of the service-oriented enterprise, focused on the use of services to orchestrate business processes across the boundaries of the enterprise and to choreograph them into a network of partners to offer value propositions to customers.

Hence, from this perspective, the terms service-orientation, service-oriented architecture, cloud, cloud computing, and services computing are re-branded to reflect their true intent of technical abstraction and their ultimate purpose of delivering business benefit. In this view, "the Cloud" embodies a business technology platform and service-oriented design philosophy to enable the enterprise to dynamically establish new business processes and business models based on partnerships. The promise of service-oriented architecture and cloud computing is to enable interoperability and collaboration between the enterprise and business partners by reducing the constraints of differences in underlying technology and barriers of location. Thereby, enabling new capabilities, increased flexibility to exploit these capabilities, and the necessary agility to respond to future (potentially unknown) business requirements. In this study a distinction is made between flexibility and agility, where flexibility focuses on the actions to manage predictable change with a predetermined response and agility focuses on the actions to manage unpredictable change, potentially in an innovative manner.

In this study, having achieved some degree of abstraction from the underlying technologies enabling a focus on leveraging technologies to achieve business objectives, insight is offered on the construct of business process management. This research agenda is based on the principle that business strategy is enabled by business processes, and therefore enterprise agility is a function of business process agility. The term business process agility is defined as the ability of an enterprise to adapt its business processes to changes in the market and is operationalized as the range of business integration capabilities and the speed to configure and deploy these capabilities. In this study, a holistic perspective of business process agility is demonstrated, founded on business services, used to orchestrate multi-enterprise business processes, and combined together to establish service systems and value networks. In the context of service-oriented process management, the hierarchy of action is defined in terms of business process instrumentation, business process orchestration, and business process choreography. The notion of business process improvisation is introduced in this research study as an action to pursue experimentation in process design as an outcome of the inherent flexibility and agility of the cloud-based service-oriented architecture designed, implemented, and evaluated in the case study environment.

Collectively, the results from the study offer a business-oriented perspective of key terms and constructs that are commonly discussed in practice and research from a predominately technology perspective. Reiterating the important point, the intent and promise of service-oriented architecture and cloud computing is to abstract the enterprise from the technical complexities, thereby enabling increased organizational flexibility and agility to focus on business objectives. For IT professionals, embracing this view is necessary and imperative to evaluating the potential value of these service-oriented technologies to the enterprise and with it recognition that the role and value proposition of the IT organization can be shifted towards a more direct business contribution. Moreover, an appreciation of the business perspective of these constructs is necessary to understand their relationships to enable the design and implementation of IT-enabled business models. Recommendations for IT practitioners in the context of new constructs are presented as follows:

- Adopt the perspective of cloud and cloud computing as enabling technologies to achieve business transformation rather than a singular focus on rapid provisioning of computing resources and subscription-based payment models.

- Embrace services computing and service-oriented architecture as a design philosophy to enhance the organizational capability to respond to changing business requirements and opportunities. It's not about technology and can't be purchased or provided by a vendor.

- Operationalize enterprise agility in terms of capabilities and speed to design and deploy business processes that are supportive of business objectives and strategies. Recognize the differences between business process flexibility (response to known requirements) and business process agility (response to unknown requirements).

Models. In design science research in information systems a model is a set of statements to express relationships among constructs that represent the problem and solution situations. In this study, three emerging models were designed and implemented offering insight and recommendations to IT practitioners and potential for future scholarly research. The three models pursued in this study are a cloud-based business integration platform (cloud-based service-oriented architecture), a cloud services brokerage model, and the service-oriented enterprise as a business model. The cloud-based integration platform delivers the service-oriented infrastructure upon which managed services are provisioned using a cloud services brokerage model, to enable the realization of a service-oriented enterprise. An overview of each of the models designed and employed in the study is provided below.

In this study, the design and deployment of a cloud-based business integration platform was pursued to address a gap in the existing IT solution space, namely to cost-effectively deliver enterprise business integration technologies that would accommodate both traditional and emerging integration use cases. The study pursued two concurrent design phases, the primary design activities to develop the platform upon which the enterprise conducts the secondary design of multi-enterprise business processes. The cloud integration platform leveraged the converged benefits of a service-oriented architecture and cloud computing to cost-effectively deliver enterprise-class integration capabilities. The resulting integration Platform-as-a-Service is one of the first known deployments of this type in practice and thus offers guidance for IT professionals and future scholarly research.

The second model designed, implemented and evaluated in this study is the cloud services brokerage model. As described, cloud services brokerage is an emerging business model that delivers managed services to address the technical complexities of the growing number and types of cloud services available to the enterprise. In the most general terms, cloud brokers provide intermediation services to help the enterprise to effectively leverage cloud services, particularly when they span multiple cloud service providers. The design and deployment of the cloud services brokerage model in this study, along with the integration Platform-as-a-service, represents the first and most comprehensive deployments of this type in practice. This study has been cited as an example of an emerging type of a cloud broker, the inter-cloud broker (ISB) focused on the integration of networks ("hyper-hybrid") of cloud providers. As such, this study provides a unique perspective to define cloud services brokerage and its role in the enterprise.

As with service-oriented architecture and cloud computing before, early promoters of the cloud services brokerage model have emphasized the technical considerations and benefits of this emerging model. This research takes a contrarian view, arguing and demonstrating that the promise of cloud services brokerage is to reduce technical complexities and enable the enterprise to focus on business goals and objectives. This research uniquely positioned and leveraged cloud services brokerage as a model to enable business partner integration and interoperability. Moreover, this study expands the scope and applicability of cloud brokerage beyond the consumption of cloud-based services to also encompass business-to-business integration, as the combination of traditional and emerging integration reflects the reality of today's business environment and the opportunity for differentiation.

The final model pursued in this study is the service-oriented enterprise. As described, a service-oriented enterprise pursues an aligned business and technology strategy to integrate its internal business processes with those of a network of business partners for the purpose of value creation. Technically, this is accomplished through the adoption of the paradigm of services-computing by aligning business services with technology services as a means to design and deploy flexible business processes. In this study, the architecture of the service-oriented enterprise consists of a technical architecture, overlay architecture, and a business architecture upon which enterprise users conduct the ongoing composition, orchestration, and choreography of multi-enterprise business processes in support of business objectives.

In today's digitally networked service economy, firms are increasingly forming partnerships to lower operational costs and to offer new and compelling value propositions to customers. As a result, large and small firms must develop organizational capabilities and competencies to effectively and dynamically extend their business processes across the enterprise. As demonstrated in this study, the cloud integration platform and service-oriented approach to business process design has enabled a medium-sized manufacturing firm to transition to a service-oriented enterprise and achieve a business transformation. Recommendations for practitioners in the context of new models pursued in this study are presented as follows:

- Enterprises seeking a comprehensive solution to enable interoperability between their on-premise and business partner and cloud-based systems, applications, services and data should consider an integration Platform-as-a-Service that leverages a service-oriented approach to inter-enterprise business process design and management (e.g. orchestration, and choreography). Inherent in their design and business model, these cloud integration platforms can accommodate single business integration requirements (e.g. orchestration) for incremental adoption and scale as required to accommodate collections or systems of multi-enterprise business processes (e.g. choreography), as demonstrated in this study.

- Enterprises seeking to more effectively manage their business-to-business integration requirements and the complexity of the growing numbers and types of cloud services offerings should consider cloud service brokers who provide various integration services (i.e. intermediation, aggregation, and arbitrage), enhanced security, and business activity monitoring.

- Enterprises seeking a comprehensive approach to supporting a business strategy based on the formation of digital partnerships should consider a service-oriented architecture of the enterprise. The cloud architecture of the service-oriented enterprise is represented in three layers: cloud technical architecture, cloud overlay architecture and cloud business architecture.

Methods. A desired outcome of design science research in information systems is to make meaningful contributions to the IT practitioner and scholarly knowledge base of "design as a process." This involves new methods (how-to-knowledge) leading to the design of a novel IT artifact that solves an organizational problem in new and innovative ways. In this study, the methodological contribution is made in the context of how emerging cloud platforms enable a new class of secondary service-oriented design activities. This represents a fundamental shift from traditional information systems and applications to an environment that enables the enterprise to discover, select, and orchestrate business services in the ongoing creation of multi-enterprise business processes. This view of service-oriented design recognizes the existence of two design phases, one where the service is distributed to enterprise users and another where enterprise users interact with the service to address their unique business requirements. In this study, the primary design pursued a cloud platform to deliver business integration capabilities "as-a-service" to the enterprise. In the secondary design phase, the enterprise users leveraged the capabilities of the platform to discover, select, and integrate business services in a continuous cycle of design and re-design in the context of their unique and changing business environment.

As demonstrated in this study, higher levels of business process flexibility and agility were achieved in this case study environment by adopting a design philosophy that leverages the converged benefits of service-orientation and cloud computing. By representing discrete units of business functionality as loosely-coupled, reusable, and sharable services provided on-demand, the barriers of location, structure, context, and scale leading to inflexibility and rigidity in traditional information systems are greatly reduced or eliminated. Moreover, as demonstrated in the study, these emerging cloud-based platforms are in a perpetual state of design as desirable capabilities are incrementally identified, developed, and deployed based on feedback from a community of enterprise users conducting secondary designs in new and innovative ways. In many ways, this emergent approach to the design and use of information technology and systems in the enterprise emulates the phenomenon of consumer and social media platforms (e.g. Apple iTunes, Google Docs, Facebook, and Twitter).

As increasing numbers and types of cloud business technology platforms become available to the enterprise, an understanding of the phenomenon of secondary design becomes more important. Secondary design is the process by which users modify technology in the context of use and represents a fundamental shift in how the enterprise interacts with information technology and systems to deliver business value. In this study, secondary design activities leveraged the cloud integration platform to design and deploy business processes across and beyond the enterprise. In this environment, enterprise users are largely abstracted from the underlying technical complexity and interact with a repository of private and publically available business services to construct and deploy a wide range of business processes. As demonstrated in this study, the cloud architecture delivered the necessary business process agility to enable the enterprise to conduct a hierarchy of secondary design activities. In this environment, multi-enterprise business processes are efficiently designed (orchestrated) to integrate business partner capabilities into the enterprise and combinations of business processes are designed (choreographed) to establish service systems and networks that offer value propositions to customers beyond what the enterprise can achieve alone.

Three types of secondary designs emerged from the study exhibiting characteristics of being transactional, differentiated, or innovative in their outcomes. Most of the business process designs in this study are characterized as transactional with well-defined specifications that pursued operational efficiencies. However, as business services and business processes are orchestrated and choreographed into unique combinations by enterprise users they become more differentiated (unique in the market) and innovative (unique across markets). The increased business process agility enabled by the cloud integration platform is conducive to the discovery and experimentation of new types and combinations of business processes. Moreover, the results from the study suggest as business demands become more specialized and situational, secondary design processes exhibit characteristics of being improvisational.

Findings and recommendations for practitioners in the context of new methods pursued in this study are presented as follows:

- Emerging cloud-enabled business technology platforms exhibit interrelated primary and secondary design phases. Enterprises evaluating the potential of cloud platforms should consider platforms that are designed for both known and unknown requirements and are adaptive to feedback from secondary design activities.

- Emerging cloud business technology platforms enable enterprise users to interact and modify technology to conduct secondary designs in the context of use. Secondary design is an emerging service-oriented design paradigm that leverages cloud-based platform and repository of services to compose, orchestrate, and choreograph business processes.

- The business process agility enabled by the cloud platform designed in this study results in different types of secondary designs in response to unique business requirements and opportunities. Secondary designs of business processes may exhibit characteristics of being transactional, differentiated, innovative, and potentially improvisational.

- The notion of business process improvisation is introduced in this research. The cloud platform, enhanced business process agility, and the service-oriented design paradigm facilitate the discovery, experimentation, and improvisation of unique combinations and sequences of new and existing business services, potentially leading to differentiated or innovative business process designs. Business process improvisation is the creative and spontaneous process involving the design and execution of a sequence of activities using available capabilities to achieve business objectives in new ways.

- Enterprises pursing a service-oriented enterprise or cloud integration platforms should consider a comprehensive perspective of inter-enterprise business process design and management, starting from business services (micro), to business processes (meso), to service systems and networks (micro).

Instantiations. The fourth and final outcome of design science research in information systems is the instantiation (representation of an abstract concept in an actual instance) of the IT artifact designed in the study. In this study, the primary design phase resulted in the incremental deployment of platform capabilities using feedback from the secondary design phase and the evaluation of the artifact in practice. As described in the methods section, the design-build-evaluate cycle is a fundamental to design science research and is differentiated from professional design by the rigor of the evaluation and contributions to the knowledge base of design. In this study, a strong relationship was demonstrated between the primary and secondary design activities, as the cloud platform incrementally evolved in capabilities across 6 releases based on the feedback from the secondary design of 56 business processes.

The results suggest the emergence of a design paradigm to build cloud-based platforms that embrace the indeterminacy in how enterprise users interact with the capabilities and that are adaptive to new and desired capabilities emerging from secondary designs. Moreover, the results suggest the emergence of a design process where secondary designers (enterprise users) leverage technology delivered as-a-service in new and powerful ways in their unique contexts to achieve business requirements.

The instantiation of the cloud integration platform and multi-enterprise business processes offers practical and actionable guidance for IT practitioners. As cited in the Gartner case study, the cloud platform designed and demonstrated in this study eases the adoption of cloud computing in the enterprise. In particular, the cloud platform delivers the necessary technical and managerial capabilities to integrate a single (or many) cloud service(s) into internal business systems, applications and processes. As this cloud architecture employs a secure network connection between the enterprise and cloud service providers it mitigates many of the common concerns associated with the adoption of cloud computing to include integration, security, and reliability. Although these are significant and important concerns for IT practitioners, this research moves beyond cloud computing adoption towards a more holistic business technology platform that is responsive to business needs and change.

This research advances the understanding and perception of the business value of a service-oriented architecture and cloud computing through application and evaluation in practice. This study demonstrated how the convergence of a service-oriented architecture and cloud computing enables new and powerful platforms upon which the enterprise creates dynamic business models. This represents a fundamental shift from service-oriented architecture deployments that focused on the technical considerations of rationalizing a diverse portfolio of internal applications in large enterprises to a perspective of integrating the capabilities of business partners of any type or size enterprise. By delivering a robust set of integration capabilities as-a-service, the service-oriented architecture extends beyond the enterprise and enables a shift from a focus on technical considerations to business objectives, from large-scale deployments to achieving incremental benefits, and from capital expenditures to a pay-for-use model. This view is particularly relevant to small and medium-sized enterprises that heretofore did not have the resources to pursue a service-oriented architecture. In addition, many small and medium-sized enterprises have already embraced cloud computing for their enterprise systems and lack an overall architecture to effectively integrate cloud providers into their internal business systems, applications, and processes.

The results from this study suggest that enterprises of all sizes could realize benefit from the adoption of a cloud integration platform and cloud services brokerage model. The cloud-based architecture and cloud services brokerage model demonstrated in this study could be employed to ease the adoption of cloud computing, to more effectively manage an existing portfolio of cloud deployments, and to enable a comprehensive business strategy leading to a transition to a service-oriented enterprise. Recommendations for information technology and business practitioners emerging from the instantiation of the artifacts pursued in this study are presented as follows:

- The convergence of the principles of service-oriented architecture and cloud computing embodied in a cloud business integration platform have been demonstrated to enhance business process agility in this case study environment, thereby enabling the flexible and efficient design of a wide-range of inter-enterprise business processes. Practitioners may consider emerging service-oriented cloud platforms as a cost effective means to design and deploy flexible business processes.

- Enterprises should consider cloud integration platforms and cloud brokerage to address business integration requirements. The cloud integration platform demonstrated in this provides a unified architecture to design and deploy end-to end business processes with traditional business partners and emerging cloud providers. This approach facilitates a focus on business objectives, eliminates significant purchase costs for similar capabilities, and supports incremental deployment of functionality with immediate benefits.

- The application of the constructs, models, and methods as recommendations above has enabled a transition of a manufacturing firm towards a service-oriented enterprise. This transition demonstrated significant benefits in the case study environment to include both increased operational efficiency and revenue growth by leveraging the capabilities of external partners to reach new customers with new and innovative product and service bundles. These constructions, models, and methods

In summary, the desired outcomes of design science research in information systems (new constructs, methods, models, and instantiations) provide a useful framework to present the contributions and recommendations that have emerged from the study and suggestions for future research. This research provided clarity and meaning to terms and constructs used to describe the phenomenon of service-orientation and its actual benefits to the enterprise. In particular, the research addressed the absence of a business perspective when defining and describing enablers such a cloud, cloud computing, and service-oriented architecture as well as their business benefits in terms of flexibility and agility. This research introduced three emergent and related models supportive of the realization of a business strategy based on the dynamic formation of a network of business partnerships. Together, the cloud integration platform and cloud services brokerage model designed in this study enabled the transition of a medium-sized manufacturing firm towards a service-oriented enterprise.

This research made several key contributions to the knowledge base of design as a process. The study demonstrated the importance of establishing and adhering to an overall service-oriented design philosophy to achieve the desired flexibility and agility in the designed IT artifacts. The research introduced the notion of a service-oriented design paradigm for emerging cloud-based platforms for the enterprise, consisting of a primary design phase to enable secondary designs conducted by enterprise users leveraging the technology in their unique contexts. The results informed the research question by providing insight into the design of a cloud-based architecture to enhance business process agility in the case study environment. The increased levels of business process agility afforded by the cloud platform enabled the enterprise to deploy a wide range of transactional, differentiated, and innovative multi-enterprise business processes. Moreover, the cloud integration platform provided the foundation for a comprehensive business process architecture represented by a hierarchy of micro, meso, and macro levels as a guiding framework for the design of business services (micro-level instrumentation), business processes (meso-level orchestration), and business networks (macro-level choreography). The cloud-based architecture that was designed, and demonstrated during this study represented by the foundational technology architecture, an abstraction or overlay architecture, and business architecture enabled Mohawk's transition towards a service-oriented enterprise and realization of significant business results.

5.3.3 Recommendations for Future Research

In this final section of the thesis this researcher presents his perspective of how enterprise systems will evolve in the coming years and how this study provides a foundation for future research. Arguably, the artifacts designed and implemented in the study provide insight as to how enterprise systems will be designed, delivered and used in the future. In the 1990's enterprise systems emerged in response to the need for a comprehensive set of business functionality to integrate disparate applications, business processes, and information flows. However, over the last two decades enterprise systems have become well-known for their monolithic structure, inflexibility in response to change, vendor lock-in, and exorbitant purchase cost and annual maintenance fees. In part because of these concerns, enterprises have begun to embrace a cloud-based software delivery and subscription model for vertical applications. As consequence, most enterprises now have a hybrid computing environment consisting of both on-premise and cloud-based applications.

These cloud applications offer new business capabilities that can be deployed rapidly and cost effectively, however they also resurrect some of the challenges of disparate business processes and information flows that enterprise systems sought to address several decades prior. Arguably, with the proliferation of cloud-based applications and services, disparate systems, business processes, and information flows will once again become an increasing concern for the enterprise. Therefore, placing an increased importance on cloud integration platforms and cloud service brokers, such as those demonstrated in this research, as a solution to this growing integration problem.

In this context, it is argued that we are approaching an inflection point where the increasing number of cloud services available to the enterprise will diminish the role and relevance of contemporary monolithic enterprise systems. As increasing numbers and types of cloud services become available to the enterprise, more and more business functionality currently resident in enterprise systems will transition to external service providers. Using Mohawk as an example, just five years ago approximately 95% of business functionality was delivered by a single enterprise system. Today, less than 30-40% of business functionality is delivered via a single enterprise system as the remaining business functionality has shifted to “best-of-breed” systems residing on-premise or hosted in the cloud. In the coming years, with the accelerated growth in the number of cloud providers and the types of services offered, the rate of decline of the use of business functionality currently delivered by enterprise systems will increase. The functionality remaining in enterprise systems will become increasingly transactional, serving as the system of record for financial reporting, thus delivering highly commoditized business processes and becoming less of a source of differentiation.

There are several significant findings that emerged from this research that suggest why the number and types of business services available to the enterprise will continue to increase and why this is important to the enterprise. First, from a business process perspective, this research does not make a distinction between the services (capabilities and competencies) provided by traditional business partners (e.g. manufacturers, logistics providers, financial institutions) and business services provided by cloud service providers. In today’s digitally connected economy, both the number of business partnerships and cloud service providers are increasing. As demonstrated in this study, the digital interactions of traditional partners and emerging cloud providers converge as they are choreographed into combinations to form dynamic service systems and networks. Also as demonstrated in this study, the integration of traditional business partners and emerging cloud providers reflects the reality of today’s business environment and their effective integration becomes a source of differentiation.

Secondly, as the granularity of cloud-based services becomes “finer” to represent smaller units of business functionality, the number and types of cloud services made available to the enterprise will increase exponentially. Examples cited in the research include fine-grained business services to provide inventory availability and pricing for a product, to calculate a freight rate for a shipment, and to calculate a currency exchange rate for a customer. This researcher envisions an environment in the next 3-5 years where cloud brokers (such as StrikeIron used in this study) will make many thousands of business services available on-demand and ready for consumption into enterprise business processes. These cloud-based business services, ranging from address verification to payroll processing provide a finer level of business granularity than today’s vertical software-as-a-service (SaaS) applications (i.e. SalesForce.com provides a set of integrated functionality to support sales processes).

This researcher advocates that the commonly accepted definitions of cloud computing and cloud brokerage should be expanded to reflect the increased prominence and importance of fine-grained business functionality delivered on-demand to the enterprise. The National Institute of Standards and Technology and other standards organizations should consider expanding the cloud computing taxonomy to encompass fine-grained business functionality delivered as-a-service. In particular, the inclusion of an additional cloud computing service delivery model called Component-as-a-Service (CaaS), which is distinct from Software-as-a-Service (SaaS), defined as a discrete unit or component of business functionality delivered on-demand for consumption in business processes. Recognition of the growth and importance of business components delivered on–demand will encourage further research to enhance the capabilities of cloud integration platforms, the expertise of cloud brokers, and secondary design techniques used by the enterprise to deploy inter-enterprise processes and networks.

Following the trajectory of an increasing number of digital partnerships, the proliferation of fine-grained business functionality offered on-demand as-a-service, and the decomposition of enterprise systems, the new methods and models designed in the study take on increasing importance. Without consideration to these methods and models, enterprises potentially risk reversion to information architectures consisting of rigid point-to-point interfaces and fragmented business processes and information flows prevalent prior to the advent of enterprise systems. Moreover, enterprises that fail to integrate the capabilities of business partners and exploit the new functionality and favorable economics of cloud services risk competitive disadvantage or obsolescence. This researcher argues that firms that remain entrenched in their monolithic enterprise systems will not be well positioned to effectively compete in the digitally connected service economy. With the increasing trend towards the commoditization of both information technology (Carr, 2004) and business processes using enterprise systems (Davenport, 2005), the path forward to achieve and sustain competitive advantage is to develop organizational capabilities and competencies to effectively integrate their business partners into end-to-end business processes. Moreover, the most successful companies will be able to adapt their business strategies in response to changing business demands through flexible, agile and innovative business process designs.

The cloud integration platform and cloud brokerage model designed and demonstrated in this research represents an innovative and compelling approach to effectively respond to market changes and to achieve substantial business results. The study demonstrates that by embracing the converged benefits of service-orientation and cloud computing the focus of the enterprise shifts from technology to business process orchestration and choreography. The study also offers a glimpse into a future computing environment where many thousands of fine-grained business services are available on-demand for consumption into enterprise business processes. This researcher argues the proliferation of fine-grained cloud services elevates the importance of a secondary design paradigm in which enterprise users leverage a business technology platform to orchestrate and choreograph business processes across the boundaries of the enterprise. Moreover, with the enhanced levels of business process agility inherent in the cloud platforms and intermediation models, enterprise users will discover unique combinations of services resulting in new and innovative business processes, thus potentially leading to differentiated business models.

As this study examined nascent concepts and emerging models, future scholarly research can build upon this research to further evolve the capabilities of the cloud-based integration platform and enhance the level of understanding of service-oriented design techniques that leverage these capabilities to deliver business value. In design science research, design is a product (an artifact) and a process (set of activities). As such, the recommendations for future scholarly research are organized in the context of new and additional capabilities of the primary artifact designed in this study (the cloud-based business integration platform) and an enhanced understanding of secondary design as a process.

The primary design phase of this study resulted in an innovative cloud integration platform designed to deliver enhanced levels of business process agility in secondary design activities conducted by enterprise users. The significant outcome resulting from this design science research is represented by the cloud-based architecture of the service-oriented enterprise and the emerging constructs, models and methods it embodies. In particular, the service-oriented infrastructure at the technical layer, the integration platform-as-a-service (iPaaS) and cloud brokerage model providing abstraction at the overlay layer, and the holistic service-oriented design approach (i.e. micro, meso, and macro levels) at the business layer. The cloud-based architecture designed in the study demonstrated the capability to effectively to design and deploy transactional, differentiated, and innovative multi-enterprise business processes in the case study environment.

The cloud integration platform was explicitly designed to continually evolve functionality and capabilities based on the feedback from secondary design activities. During the two-year study, the cloud integration platform underwent six design iterations, each of which delivered incremental capabilities and functionality. Below are recommendations for future scholarly research to enhance the capabilities of the cloud integration platform and cloud brokerage model to achieve higher levels of business process agility than demonstrated in this study.

- Pursue research to design a service-oriented infrastructure that more closely conforms to the essential cloud computing characteristics prescribed by The Open Group (2011). Cloud characteristics such as utility-based and on-demand provisioning of computing resources can enable favorable economics and flexibility to scale computing resources and capabilities in response to changing business demands.

- Pursue research to expand the capabilities of the cloud-based integration platform and the value-added services provided by cloud brokers. Particular topics in need of further research include enhanced security and identity management and governance models to manage the increasingly complex network of cloud service providers, cloud brokers and inter-cloud service brokers.

- Pursue research to define the next generation cloud integration platform and brokerage model towards the notion of a cloud business process hub or utility. This envisions a cloud platform where enterprise business logic resides in a business modeling process language (i.e. BPEL, BPMN), thereby allowing improved interoperability or switching between vendor solutions. The cloud business process hub will provide enterprise users with utilities to enable the provisioning and monitoring of business process flows.

The paradigm of design science research in information systems requires a contribution to the scholarly knowledge base of design. This study builds upon prior scholarly research on service-orientation in the enterprise (Montealegre et al., 2008) that leverages primary and secondary design phases (Hovorka and Germonprez, 2011) resulting in a design paradigm that embraces co-creation in context and the indeterminacy of design outcomes (Vargo and Lusch, 2006; Chen and Vargo, 2010). Collectively, this body of research informs the flexible and dynamic design of service systems and networks (Maglio and Spohrer, 2007; Lucsh et al., 2010) and the transition towards a service-oriented enterprise (Vitharana et al., 2007; Poulin, 2009; Alter, 2012), both having the objective to efficiently integrate the capabilities of the enterprise with those of external partners to offer customers with new and innovative value propositions. The emergence of service-orientation as a means of integrating internal and external capabilities and competencies for value creation, has resulted in a call from scholars to research new approaches to Service Science (Maglio and Spohrer, 2007; Spohrer and Kwan, 2008; Wolfson et al., 2010) and Design Science (Hsu, 2009; Chen and Vargo, 2010).

The discipline of design science research in information systems offers significant potential to help scholars and practitioners conduct research in pursuit of new and innovative uses of information systems to address a wide range of organizational challenges. In the literature, consensus seems to be building on design science research processes and models to conduct and evaluate high-quality design science research (Peffers et al.; 2007; Hevner, 2007; Hevner & Chatterjee, 2010). However, there is substantial learning potential resulting from more reflection of the design science research in information systems methodology in terms of both relevance and rigor. Arguably, a number of aspects of the design science research pursued in this study are noteworthy and potentially areas of contribution to enhance existing design science research in information systems guidelines and process models.

The iterative cycle of design-build-evaluate is core to design science research in information systems (Hevner, 2007) requiring evaluation and subsequent feedback until a satisfactory IT artifact is realized (Simon, 1996). A strength and potential contribution from the conduct of this study is the extension of Peffers' process model to include a design-build-evaluate cycle within a design-build-evaluate cycle. Specifically, in the pursuit of the design of a primary IT artifact (cloud integration platform) enabling the on-going secondary design of IT artifacts (multi-enterprise business processes), resulting in the perpetual design of the primary artifact in a continuous cycle. This design-build-evaluate loop may represent a new design paradigm for emerging cloud platforms that empower enterprise users to leverage technology provided on-demand to conduct secondary designs in their unique context, and thus a contribution to the design science research process model.

Another potentially unique contribution emerging from this study is the scope and breadth of contribution across the prescribed design science research outcomes in terms of constructs, models, methods, and their instantiation in practice (March and Smith, 1995). Most design science research focuses on one of the outcomes and often does not lead to full instantiation in a "real-world" environment, thus potentially limiting a full explanation of transferability and applicability in other contexts (Miles and Huberman, 1994).

A particular strength of this study is the relevance of the research agenda and the recognition of the importance of the research by professional audiences. Upon reflection, the relevance of the study outcomes can be associated with several factors. First, this study provided a unique opportunity for an insider researcher to study a highly relevant topic in an "exemplar" case study environment in terms of a progressive approach to technology adoption. Second, the professional doctorate program of the Syracuse University School of Information Systems with the mission to bridge practice (i.e. relevance) with academia (i.e. rigor) provides access to both academic and practitioner expertise. Design science research in information systems conducted in the context of a the iSchool's professional doctorate program focused on the discipline of information management and systems may serve as a model to address some of today's most pressing challenges, while also advancing the methodological rigor of design science research in information systems.

There is also opportunity for reflection and learning to enhance the rigor of the design science research in information system process. Reflecting upon the conduct of this study, two aspects of the design science research in information systems process would benefit from detailed methodological guidelines. The first is related to the demonstration of the desired IT artifacts novelty and the second is related to the rigor in the conduct of the testing and evaluation of the IT artifact. For example, how does the researcher know that all design alternatives have been considered or know with some level of certainty that no similar artifacts exist in the solutions space? The primary differentiator between professional design and design science research in information systems is the rigorous and convincing evaluation of the IT artifact designed and developed (Pervan and Arnott, 2005; Iivari, 2007). Thus, how does the researcher and readers of the study assess the sufficiency or rigor of the evaluation methods employed? The intent of the evaluation phase of design science research is to demonstrate how well the designed IT artifact meets the pre-determined design requirements and how well it addresses the stated research problem. Fundamentally, it is the responsibility of the researcher to establish a clear and congruent connection between the research problem, the methods employed to answer the question, and to evaluate the quality of the research. However, the evaluation methods employed can vary depending on the type of IT artifact developed and the resources available to the researcher (Levy & Ellis, 2006). Another challenge, rigorous testing and evaluation methods are known to be difficult to apply in design science research (Tichy 1998; Zelkowitz and Wallace 1998). For the purposes of this study, the testing and evaluation criterion was purposely rudimentary, where the evaluation demonstrated the use of two business services and the successful information exchange through the cloud integration platform. Additional guidelines in design science research in information systems frameworks could specify the necessary and acceptable methodological rigor in the evaluation phase, thereby helping to distinguish the conduct of design science research from that of professional design.

In the context of these scholarly works this research study provides insight into emerging service-oriented design techniques and demonstration of actual business benefits derived from their application in practice. In particular, that the convergence of service-oriented architecture and cloud computing delivers higher levels of business process agility to enable the transition towards an emerging architecture of the enterprise, the service-oriented enterprise. As the research pursued nascent concepts, leveraged emerging technologies, and represents the first known case study on the design and deployment of a cloud integration platform in practice, further design science research is required to advance understanding and applicability of these concepts, technologies, and design methodologies in practice. As such, below are recommendations for future research that builds upon previous scholarly works and the findings and contributions that emerged from this study.

- This study demonstrated that emerging cloud platforms have multiple design phases, the primary design of the cloud platform and ongoing secondary designs leveraging the capabilities of the cloud platform. Research is required to understand how emerging cloud platforms should be designed to enable enterprise users to interact with the platform to efficiently and dynamically select services and choreograph systems of multi-enterprise business. Design science research in information systems, and the thorough evaluation of the nuances of why and how users interact with cloud platforms for their unique purposes, would contribute to the effectiveness of these emerging platforms in the enterprise.

- The comprehensive scope of outcomes from this study represented as constructs, models, methods, and instantiation in practice is believed to be an "exemplar" in design science research in information systems. The conduct of design science research in information systems in the context of a unique professional doctorate program serves a model to solve complex and contemporary challenges in the domain of information systems and advance the quality (both relevance and rigor) of design science research in information systems.

- The rigorous evaluation of design alternatives and the evaluation of the designed artifacts adherence to the design requirements were cited as potential weaknesses in the conduct of this study. The quality (rigor) of design science research in information systems would be enhanced by additional frameworks, guidelines, and processes to ascertain the adequacy of evaluation methods to guide future design science researchers and to help readers of the study assess its quality and applicability.

- This study demonstrated a secondary design methodology that leverages a repository of business services and the capabilities of a cloud platform to orchestrate combinations of multi-enterprise business processes. Additional research is required to understand the phenomenon of secondary design and how and why a service-oriented approach delivers flexibility, agility and innovative designs of business processes in the context of their use.

- This research suggests that secondary designs of multi-enterprise business processes exhibit characteristics of being transactional, differentiated, innovative, and potentially improvisational. Further research is required to understand how and when to pursue each type of design in response to the unique context of the enterprise and their business requirements and opportunities.

- This study introduced the notion of business process improvisation as an outcome of the capabilities of the cloud integration platform and pursuit of service-oriented business process designs. Research is required to understand the organizational determinants of business process improvisation and how and when to adopt this design approach to achieve business results.

- This research demonstrates how fine-grained units of business functionality available on-demand can be orchestrated into enterprise business processes. Further research is recommended to incorporate the notion of Component-as-a-Service (CaaS) into the cloud computing taxonomy to understand how these cloud-based components can be effectively integrated into enterprise business processes and to develop governance processes to maximize the reliability and security of this capability.

- This research presents a cloud-based architecture of a service-oriented enterprise that abstracts users from technology to enable a focus on the hierarchical design of business services, processes, and service systems and networks. Further research is necessary to develop design techniques to orchestrate business processes and to choreograph them into dynamic services systems that deliver business value.

- This study demonstrated how a cloud integration platform and cloud services brokerage enabled enhanced business process agility and the transition towards a service-oriented enterprise. Research is required to demonstrate the transferability and applicability of the constructs, models, and methods outside the case study environment. The constructs and models defined and informed in this study have applicability across a broader context as they represent a set of principles and guidance potentially applicable to IT practitioners. The capabilities of the cloud integration platform and the value-added services of the cloud services brokerage model may be leveraged to integrate partners or cloud providers in an incremental manner.

- The service-oriented enterprise potentially represents the architecture of the future to achieve and sustain competitiveness in the networked service economy. This research demonstrates that this transition is less about technical imperatives and more about organizational capabilities. To exploit the potential of the service-oriented enterprise, further research is required to understand how value propositions are offered in service system interactions and how organizational structures should be designed to encourage collaboration with business partners and customers.

- The goal of the service-oriented enterprise is to offer value propositions to its customers. This study demonstrates that in a manufacturing firm, products and services converge, and value propositions are offered in exchange, in context, and in use. Further research is required to view these as complementary rather than to distinguish products from services and value-in-exchange from value-in-context or value-in-use.

5.3.4 Research Implications and Final Thoughts

This section concludes the presentation of the doctoral thesis and offers final thoughts on how this research study may be suggestive of the future architecture of the enterprise and its supporting enterprise computing environment, and how this may change and shape the role of the information technology function and its practitioners.

This research is positioned in a digitally connected service economy and the transition of a medium-sized manufacturing enterprise from a predominant product-orientation towards a service-oriented enterprise. In part, this case study is representative of the trend towards a resurgence of goods-production and manufacturing in the U.S. economy and recognition of the importance of small and medium-sized enterprises as the backbone of the economy and as a source of flexibility, agility and innovation. Arguably, flexible and agile enterprises that produce tangible goods or products as their core competency and complement their product and service offerings with a dynamic network of business partners, may become among the most successful and sustainable type of enterprises in the coming decades.

Mohawk offers a unique environment to observe and understand the symbiotic relationship between products and different types of services and how value propositions are created and offered to customers. In particular, an environment where the firm's products are enhanced by leveraging the complementary capabilities and knowledge of a network of partners, each adding incremental value beyond what the enterprise could achieve alone. In this context, the service-oriented enterprise is the epicenter of a network of partners delivering services as products, capabilities, resources, expertise, and knowledge, purposely designed to create and offer value propositions.

This research offers an architectural approach to enable the enterprise to collaborate with a network of traditional business partners and leverage emerging cloud service providers in a comprehensive, incremental and cost effective manner. In particular, by viewing the Cloud as a business technology platform and overlay architecture to seamlessly integrate internal and external business processes, the enterprise is empowered to design and deploy business processes in a more federated way by reducing the typical barriers of security, location and underlying technology.

Moreover, this research suggests that the cloud will evolve beyond providing infrastructure, platform, and software services to deliver finer-grained units of business functionality for consumption in enterprise business processes. This phenomenon has been described as "Web 2.0" where consumers leverage the cloud as a platform to actively participate in the design (i.e. mash-up) of content in web-based applications. This research suggests this phenomenon, which is most often associated with cloud-based social media platforms, will have an increasingly important influence on how enterprise systems are designed and used.

As the enterprise computing environment becomes more federated and hybrid, the cloud integration platform will become increasingly important and will evolve to become a cloud-based business process hub. The next generation cloud integration platform will retain and manage business logic to enable seamless migration between cloud services and to create new possibilities for situational business process execution. The primary source of business process flexibility, agility and innovation will shift from the traditional enterprise systems towards cloud-based business process platforms serving as a hub for information exchange and multi-enterprise integration and collaboration. These emerging cloud platforms and business process hubs enable the realization of the service-oriented enterprise that pursues complementary capabilities, resources, and competencies of a network of business partners and service providers to offer customers new and compelling value propositions.

As demonstrated in this research, the emergence of the service-oriented enterprise and evolution of "the Cloud" as a business technology platform will have a significant impact on the enterprise computing environment. This study suggests that emerging cloud platforms will become an alternative to traditional, on-premise, monolithic enterprise systems which are associated with high costs of ownership, rigidity and inflexibility in response to change, and commoditized business processes. As a result, today's monolithic enterprise systems will become increasingly disaggregated as business functionality transitions to cloud-enabled and cloud-aware applications, services, and data. In response to potentially losing market share to a growing number of cloud providers some enterprise system vendors have cloud-enabled their core solutions or have added software-as-a-service solutions to their portfolio. Most often, this approach reverts to point-to-point integration solutions and does not adequately address the vendor lock-in, high cost, and inflexibility challenges typical of contemporary enterprise system deployments. Rather, this research embraces the paradigm of services computing as a philosophy which can't be purchased or delivered as a software solution. This vision of a cloud integration platform is one that is vendor and technology agnostic and unburdens the enterprise from the rigidity, complexity, cost, and dependency of today's enterprise systems. Moreover, this vision of enterprise computing embraces the notion of a cloud ecosystem of services that are available on-demand for consumption and orchestration into enterprise business processes, rather than a dependence on a single enterprise system or relatively few enterprise solutions providers.

This future vision of enterprise computing will have a significant impact on the role of the IT organization and practitioners in the enterprise. Most notable, and as demonstrated in this study, is the pronounced shift from a focus on managing technology towards a more direct emphasis on using technology platforms to achieve business objectives. Following the trend towards the increasing commoditization of IT infrastructure and demands for the ongoing differentiation of multi-enterprise business processes, the roles of the information technology practitioner and business subject matter expert converge. At the micro-level, technology and business practitioners work towards identifying units of functionality and representing them as shareable business services in business process designs. This activity includes the ongoing survey of publically available business services and assessment of their applicability to address business requirements in more effective ways. At the meso-level, business users collaborate with external partners to co-design multi-enterprise business processes in the unique context of their mutual goals and objectives. At the macro-level, the Chief Information Officer, in collaboration with business executives, continually identifies and evaluates new partnership opportunities. The complementary capabilities of a network of partners and cloud providers are choreographed into unique combinations of business processes to form service systems and networks to achieve a particular business objective. In this perspective of the "process-centric enterprise" (Stamas, 2009) the Chief Information Officer assumes a more prominent role as the Chief Process Officer and the information technology practitioner assumes responsibilities as a business process architect. In the service-oriented enterprise the respective strategies, roles, and responsibilities of the information technology organization and business functions begin to converge towards a common business objective. The information technology practitioner is less concerned with the enabling technology and becomes more focused on designing, deploying, and governing a comprehensive portfolio of business services, processes, and network of partners.

This research study provides insight as to what may become the structure of the enterprise of the future and the evolving role of information technology to deliver business results. In this future vision, the enterprise offers value propositions through a dynamic network of partners that offer complementary capabilities to enhance the firm's effectiveness and to provide a source of innovation for new product and service offerings. The service-oriented enterprise embraces the notion of representing discrete business functionality in the form of business services as a means to seamlessly integrate internal and external capabilities as business processes. The enterprise of the future views "the Cloud" as a platform to deliver computing resources on-demand, as a platform to discover and access thousands of business services, and as a platform to orchestrate business processes and choreograph service networks. The newly empowered business process officer and business process architects pursue the ongoing (re)design of business services (micro-level), business processes (meso-level), and service systems and networks (macro-level). They pursue the design of business processes that extend beyond the borders of the enterprise with less concern about whom or what is providing the business service, or where the business service resides, or the details of the underlying technology. In the service-oriented enterprise, business processes no longer exclusively result from on-premise enterprise systems, but rather from a federation of internal resources and complementary network of partners and cloud service providers. In this future vision, the most successful enterprises will transition beyond the design and deployment of commoditized business processes and will encourage a culture that exploits emerging cloud platforms and cloud-based business process hubs to design, deploy, and manage the range of transactional, differentiated, and innovative business processes, some of which are designed and executed in an improvisational way.

The transition to a service-oriented enterprise and exploitation of the potential of the Cloud as a business technology platform presents significant opportunities and challenges. As the enterprise computing environment becomes more federated, hybrid and granular, there are legitimate concerns about security, reliability, and complexity. Further research is required to enhance the capabilities of the next generation cloud integration platforms and the role of cloud service brokers. This vision of the architecture of the enterprise will fundamentally transform the role of information technology in the enterprise. This role is rapidly evolving towards becoming a broker of services, and integrator and manager of a hybrid portfolio of business services that includes internally developed and externally acquired services. The role of the information technology practitioner shifts from managing technology towards a more direct role in supporting business strategy execution through the discovery and design of business services and the composition of business processes. The contemporary notion of "the Cloud" will evolve from an operational platform to host applications towards a vision as a platform to establish business models based on partnerships and collaboration.

This research provides a glimpse of what might become the architecture of the enterprise of the future, one that leverages service-computing to become more agile, inter-connected, and collaborative in response to the ongoing change in a digitally connected service economy. As this case study is positioned at the intersection of technology, organizations and people, the most meaningful contributions building upon this case study and design science research will provide increased understanding of how individuals interact with cloud platforms and how enterprise users leverage these new and powerful capabilities to deliver transactional, differentiated, and innovative business processes in response to market demands.

A few final thoughts and observations regarding the conduct of this research in the context of the Professional Doctorate program at the School of Information Studies (iSchool) at Syracuse University. The iSchool has maintained its number one ranking in Information Systems in *U.S. News & World Report's "America's Best Graduate Schools"* over the last four years (2009 – 2012). Keeping with its tradition of excellence and innovation in education, the iSchool launched the Professional Doctorate program in 2009, of which this researcher was one of five students in the inaugural class. The mission of the Professional Doctorate program is to develop a new breed of information management professionals that can help bridge academic research with practical relevance.

The Professional Doctorate program offers a unique and innovative environment to address the most significant challenges and opportunities confronting society, organizations, and information management professionals. The program leverages a vast tradition of scholarly research and the experiences of practicing professionals to contribute to new understanding of problems at the intersection of organizations, people and information systems. This research was guided by a doctoral committee with considerable professional experience and was conducted in the context of an academic-industry partnership in a case study setting known for its innovation in the application of information technology to address business problems. The outcomes from this research have had a significant impact in the case study environment and have made meaningful contributions to the knowledge-base of design. As importantly, the Professional Doctorate program has established a pathway for Mohawk and this researcher to pursue new understanding and opportunities at the convergence of the physical (paper) and virtual worlds.

LISTING OF KEY TERMS AND DEFINITIONS

Business Process – defined as a collection of business services, invoked in a particular sequence with a particular set of rules, to achieve a business requirement. Business processes are the structure by which an organization does what is necessary to produce value for its customer (Davenport, 1992).

Business Process Agility – defined as the capability of the enterprise to dynamically modify and reconfigure business processes from a broad range of business process capabilities to accommodate required and potential needs of the enterprise (Raschke et al., 2005).

Business Process Choreography –defined in this study as the co-ordination of a collection of internal and external business processes to form a service system or service network with the goal to achieve an overall business strategy or objective.

Business Process Improvisation – a construct introduced in this research to describe the creative and spontaneous process to design and execute a sequence of activities using available capabilities to achieve a business objective in new ways.

Business Process Orchestration – defined in this study as the co-ordination of business services and their interaction to form a multi-enterprise business process to achieve a specific business function or objective.

Business Service – defined as business functionality that can be composed with other business services to create a solution, or a general term that describes work that supports a business functions but does not produce a tangible product.

Cloud - the "Cloud" is a metaphor for a network of computing resources accessible over the Internet and represents an abstraction of complex infrastructure which is concealed from the end-user (Sultan, 2010).

Cloud Architecture – defined as the structure of the components, their inter-relationships, and essential principles involved in the delivery of cloud computing to include guidelines governing its design and evolution over time (The Open Group, 2008).

Cloud Broker – defined as an entity that manages the use, performance, and delivery of cloud services and negotiates relationships between cloud providers and cloud consumers (Lui et al., 2011). Cloud brokerage is an intermediation model for business technology initiatives that are cloud-centric (Lheureux et al., 2011).

Cloud Computing – Cloud computing represents a style of computing where dynamically scalable resources are provided as-a-service through internet technologies (Liu et al., 2011). Cloud computing providers offer services according to three models: infrastructure-as-a-service, platform-as-a-service, and software-as-a-service (Mell and Grance, 2011).

Cloud-Oriented Architecture – defined as a conceptual model encompassing all elements in a cloud environment. The systems architecture of the software systems involved in the delivery of cloud computing, involving multiple cloud components communicating with each other over a loose-coupling mechanism such as a messaging queue.

Cloud Overlay Architecture – a term used in this study to represent "the cloud" as a business technology platform to integrate on-premise and cloud-based systems, applications and data to design, deploy and govern multi-enterprise business processes. The objective of the cloud overlay architecture is to abstract the infrastructure from the business users and support intermediation for business process design.

Cloud Component-as-a-Service (CaaS) – a term introduced in this study used to describe a discrete unit of business functionality or business logic offered and delivered on-demand for consumption in enterprise business processes.

Cloud Data-as-a-Service (DaaS) – a term used in the study to describe the capability to provide consumers with data (e.g. file, text, image, sound, and video) on-demand, typically accessed via web-services for composition or "mash-up" in enterprise applications and web-browsers.

Cloud Infrastructure-as-a-Service (IaaS) - defined as the capability provided to the consumer to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications (Mell and Grance, 2011).

Cloud Integration Platform-as-a-Service (iPaaS) – defined by Gartner as a suite of cloud-services designed to address a range of cloud, business-to-business, and on-premise integration and governance scenarios (Pezzini and Lheureux, 2011).

Cloud Platform-as-a-Service (PaaS) - defined as the capability provided to the consumer to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider (Mell and Grance, 2011).

Cloud Software-as-a-Service (SaaS) – defined as the capability provided to the consumer to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (Mell and Grance, 2011).

Cloud Services Brokerage (CSB) - Gartner describes cloud services brokerage as a form of intermediation for business technology initiatives that are cloud-centric. Cloud service brokerage as a model adds value to one or more cloud services on behalf of one or more consumers of those services centric (Lheureux et al., 2011).

Enterprise Architecture – Enterprise Architecture (EA) is defined as both a management program and documentation method that together provides an actionable, coordinated view of the enterprise's strategic direction, business processes, information flows, and resource utilization (Bernard, 2005).

Enterprise Agility - enterprise agility is defined as the ability of firm to sense environmental change and respond readily (Overby, et al., 2006) and is enabled by the adoption of service computing (Zhao, et al., 2007). In this study, enterprise agility is defined as the capability of the firm to effectively respond to environmental threats and opportunities through business process design and deployment.

Enterprise Integration – There are at least four types of enterprise integration (e.g. A2A, B2B, C2P, and C2C). Application-to-application integration (A2A) is the transport and synchronization of data between intra-enterprise systems or applications. Business-to-business (B2B) integration is the exchange of information between internal systems and the systems and applications of business partners and customers. Cloud-to-on-premise (C2P) and cloud-to-cloud (C2C) integration is the exchange of information between on-premise and cloud-based applications, systems, and services.

Inter-Cloud Service Broker (ISB) - defined as an entity that enables interconnection (interworking and brokerage services) between two (or more) cloud service providers (Shao et al., 2011) to enable the realization of cloud-to-clouds integration or "hyper-hybrid clouds" (Deloitte, 2012).

Meso-Architecture – a term and construct introduced in this research to describe cloud architecture (process and product of planning, designing and constructing) as a platform for multi-enterprise business process orchestration and choreography. The meso-architecture resides in the cloud, leveraging business services (micro-architecture) to design service value networks (macro-architecture) to enable a business strategy based on partnerships.

Multi-Enterprise Business Process - defined as a business process that spans enterprise boundaries where two stakeholders participate in a collaborative business activity (Gartner, 2011) and network of value-added activities, performed by their relevant roles or collaborators, to purposefully achieve the common business goal (Ko, 2009).

Services Computing – a computing paradigm that integrates the science and technology of aligning business services and information technology services (Zhang, 2005) with the goal of establishing the technological and managerial foundation to enhance business process agility (Zhao et al., 2007).

Service Interaction – a term used in this study to describe the technical integration of two (or more) disparate business services to facilitate information exchange. Service interactions when described in a business context represent a business processes.

Service-Orientation –generally defined as a set of organizational policies, practices, and procedures intended to foster the creation and delivery of service excellence (Lytle and Timmerman, 2006). In information systems service-orientation is defined as a design paradigm based on services and service-based development (The Open Group, 2009) to develop and deploy information systems and business processes in the form of loosely coupled services with operating systems and other technologies that underlie applications (Erl, 2004).

Service-Oriented Infrastructure (SOI) - is the application of "service-oriented principles in infrastructure" or an architecture that defines the IT infrastructure in terms of services, thereby enabling the realization of a service-oriented architecture (The Open Group, 2009).

Service-Oriented Cloud Computing Infrastructure (SOCCI) – is a service-oriented, scalable, and on-demand infrastructure that supports the essential cloud computing characteristics, service, and deployment models (The Open Group, 2011).

Service-Oriented Architecture (SOA) – views every application or resource as a service implementing a specific, identifiable set of (business) functions. Services communicate with each other by exchanging structured information, messages or documents. SOA is also a set of principles and methodologies for designing and developing software in the form of interoperable services or an architectural style that supports service-orientation - a way of thinking in terms of services, service-based development and the outcomes of services (The Open Group, 2009).

Service-Oriented Enterprise (SOE) – defined as an aligned business and technology strategy to enable interoperability between internal enterprise business processes with the business processes of a network of business partners for the purpose customer value creation (Poulin, 2009).

Servitization - defined as the tendency of manufacturing enterprises to extend their product offerings towards providing service (Fang et al., 2009), resulting in a combined product and service bundle.

Service-Dominant Logic (S-D Logic) – a marketing logic that defines “service” as the application of competencies (knowledge and skills) for the benefit of another party. A Goods-Dominant Logic (G-D Logic) is centered on the good or product where the tangible good and intangible services are described as units of production (Vargo and Lusch, 2004).

Service Systems – service systems are defined as configurations of resources, including people, organizations, shared information, and technology, connected internally and externally to other service systems by value propositions (Maglio and Spohrer, 2007).

Service Science - is an interdisciplinary approach aimed at understanding and innovating service systems (Spohrer and Kwan, 2008). Service Science is a discipline to merge technology with an understanding of business processes and organization and to understand how that capability can be delivered in an efficient and profitable way (Horn, 2005).

Service Value Network (SVN) – defined as the configuration of service systems that leverage the resources of service providers to co-create value (Blau et al., 2009; Holweg and Pil, 2006), thereby adding incremental value to the overall product and service offering (Basole and Rouse, 2008).

Small and Medium-Sized Enterprise (SME) - small and medium-sized enterprises in the manufacturing sector is defined by the Small Business Administration (SBA) as organization having less than $500 million in total annual sales or fewer than 1000 employees (SBA, 2011).

Value-added Network (VAN) - is a hosted service offering that acts as an intermediary between business partners sharing standards based or proprietary data (traditionally transmitted data formatted as electronic data interchange)via shared business process (Patcha, 2009).

Value Propositions – enterprises offer value propositions to potential consumers that are embedded in a particular products and/or services that will add more value or more effectively solve a problem than other similar offerings (Vargo and Lusch, 2008).

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DATASET OF SECONDARY DESIGNS

Service Interaction						Originating Service (S_0)					Cloud Service Broker (CSB)								Terminating Service (S_T)					
SI_ID	SI_BUS_PAT	SI_DESIGN	SI_DEMO	SI_EVAL	SI_DEMO_DATE	S_0_BUS_ID	S_0_INT_ID	S_0_INV_TYPE	S_0_OWNER	S_0_BUS_ID_DES	CSB_VERSION	S_0_CONONICAL	S_T_CONONICAL	S_0_TRANSPORT	S_T_TRANSPORT	CSB_MSG_TYPE	CSB_TRANSFORM	CSB_DES_TIME	S_T_BUS_ID	S_T_INT_ID	S_T_INV_TYPE	S_T_OWNER	S_T_BUS_ID_DES	S_T_LINKAGE
SI001	2	1	1	1	04/01/08	S001	S018	1	2	0	P02	1	1	2	2	2	1	25	S002	S019	1	1	1	S003
SI002	2	1	1	1	04/07/08	S003	S018	1	1	1	P02	1	1	2	2	1	1	15	S004	S019	1	2	0	S000
SI003	2	1	1	1	04/15/08	S016	S018	1	1	1	P02	1	1	2	2	1	1	15	S013	S019	1	2	0	S000
SI004	3	1	1	1	04/25/08	S005	S018	1	1	1	P02	1	1	2	2	1	1	10	S006	S019	1	2	0	S000
SI005	2	1	1	1	05/01/08	S001	S018	1	2	0	P02	6	1	4	4	2	2	20	S002	S019	1	1	2	S003
SI006	2	1	1	1	05/15/08	S003	S018	1	1	2	P02	1	1	2	4	1	1	15	S004	S019	1	2	0	S000
SI007	2	1	1	1	07/01/08	S001	S018	1	2	0	P02	1	1	2	2	2	1	10	S002	S019	1	1	2	S003

SI008	2	1	1	1	07/10/08	S003	S018	1	1	2	P02	1	1	2	2	1	1	15	S004	S019	1	2	0	S000
SI009	3	1	1	1	08/01/08	S011	S018	1	4	0	P02	1	1	2	2	1	1	8	S012	S019	1	1	1	S000
SI010	3	1	1	1	08/01/08	S009	S018	1	4	0	P02	1	1	2	2	1	1	12	S012	S019	1	1	1	S000
SI011	3	1	1	1	08/15/08	S011	S018	1	4	0	P02	1	1	2	2	1	1	6	S012	S019	1	1	2	S000
SI012	3	1	1	1	08/15/08	S007	S018	1	1	1	P02	1	1	2	2	2	1	12	S008	S019	1	4	0	S011
SI013	3	1	1	1	08/20/08	S009	S018	1	1	1	P02	1	1	2	2	1	1	12	S010	S019	1	4	0	S000
SI014	3	1	1	1	09/01/08	S009	S018	1	4	0	P02	1	1	2	2	1	1	6	S012	S019	1	1	2	S000
SI015	3	1	1	1	09/01/08	S007	S018	1	1	2	P02	1	1	2	2	2	1	6	S008	S019	1	4	0	S011
SI016	3	1	1	1	09/15/08	S009	S018	1	1	2	P02	1	1	2	2	1	1	6	S010	S019	1	4	0	S000
SI017	4	1	1	1	10/07/08	S011	S018	1	1	2	P02	1	1	4	4	1	1	10	S013	S019	1	2	0	S000
SI018	2	1	1	1	03/01/09	S009	S018	1	2	0	P02	2	1	2	2	2	2	18	S002	S019	1	1	2	S003

SI019	2	1	1	1	03/01/09	S007	S018	1	2	0	P02	2	1	4	4	2	2	10	S002	S019	1	1	2	S003
SI020	2	1	1	1	03/15/09	S009	S018	1	1	2	P02	1	2	2	2	1	2	15	S004	S019	1	2	0	S000
SI021	2	1	1	1	06/01/09	S001	S018	1	2	0	P02	2	1	2	2	2	2	12	S002	S019	1	1	2	S003
SI022	2	1	1	1	06/15/09	S003	S018	1	1	2	P02	1	2	2	2	1	2	15	S004	S027	1	2	0	S000
SI023	2	1	1	1	07/01/09	S003	S018	1	1	2	P02	1	1	2	2	1	1	4	S004	S019	1	2	0	S000
SI024	2	1	1	1	07/15/09	S001	S018	1	2	0	P02	1	1	2	2	2	1	8	S002	S019	1	1	2	S003
SI025	2	1	1	1	09/01/09	S001	S018	1	2	0	P02	1	1	2	2	2	1	8	S002	S019	1	1	2	S003
SI026	2	1	1	1	10/01/09	S003	S018	1	1	2	P02	1	1	2	2	1	1	6	S004	S019	1	2	0	S000
SI027	3	1	1	1	02/01/10	S033	S018	1	4	0	P02	1	1	2	2	1	1	6	S012	S019	1	1	2	S000
SI028	3	1	1	1	02/15/10	S034	S018	1	4	0	P02	1	1	2	2	1	1	6	S012	S019	1	1	2	S000
SI029	3	1	1	1	03/15/10	S035	S018	1	1	2	P02	1	1	2	2	2	1	4	S008	S019	1	4	0	S011

SI040	SI039	SI038	SI037	SI036	SI035	SI034	SI033	SI032	SI031	SI030
2	4	2	4	3	4	2	2	4	3	3
1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1
10/15/10	09/20/10	08/01/10	07/30/10	07/25/10	07/15/10	07/15/10	07/01/10	06/01/10	05/01/10	03/25/10
S001	S016	S003	S016	S005	S016	S001	S001	S016	S003	S036
S018	S018	S018	S018	S018	S018	S018	S018	S018	S018	S018
1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	2	2	1	1	1
0	2	2	2	2	2	0	0	2	2	2
P02	P02	P02	P02	P02	P02	P02	P02	P02	P02	P02
2	1	1	1	1	1	1	2	1	1	1
1	1	1	2	1	2	1	1	2	2	1
2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	4	2
2	1	1	1	1	1	2	2	1	1	1
2	1	1	2	1	2	1	2	2	2	1
6	10	8	8	10	10	10	10	12	8	4
S002	S013	S004	S013	S006	S013	S002	S002	S013	S004	S010
S019	S019	S019	S019	S019	S019	S019	S019	S037	S036	S019
1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	1	1	2	2	4
2	0	0	0	0	0	2	2	0	0	0
S003	S000	S000	S000	S000	S000	S003	S003	S000	S000	S000

SI041	2	1	1	1	11/01/10	S047	S018	1	2	1	P02	1	1	4	4	1	2	15	S019	S019	1	2	0	S000
SI042	4	1	1	1	11/15/10	S016	S018	1	1	2	P02	1	2	2	2	1	2	10	S013	S019	1	2	0	S000
SI043	4	1	1	1	12/01/10	S016	S018	1	3	0	P02	1	1	2	2	1	1	4	S013	S019	1	1	1	S000
SI044	1	1	1	1	12/01/10	S017	S018	1	3	0	P02	1	1	1	1	1	1	8	S048	S018	1	1	1	S003
SI045	4	1	1	1	01/10/11	S024	S018	1	4	0	P03	4	8	2	2	1	2	10	S025	S027	1	1	1	S000
SI046	4	1	1	1	01/17/11	S022	S018	1	4	0	P03	4	8	2	2	1	2	12	S023	S027	1	1	1	S000
SI047	2	1	1	1	02/01/11	S001	S018	1	6	0	P02	1	1	2	2	2	1	4	S002	S019	1	1	2	S003
SI048	1	1	1	1	02/01/11	S028	S018	1	3	0	P03	8	8	2	2	1	1	6	S029	S019	1	1	1	S000
SI049	4	1	1	1	02/01/11	S030	S018	1	4	0	P03	4	8	2	2	1	2	10	S031	S027	1	1	1	S000
SI050	2	1	1	1	02/01/11	S003	S018	1	1	2	P02	1	1	2	2	1	1	2	S004	S019	1	6	0	S000
SI051	4	1	1	1	02/14/11	S016	S018	1	1	2	P02	1	1	2	2	1	1	2	S013	S019	1	6	0	S000

SI052	4	1	1	1	02/15/11	S030	S018	1	2	0	P03	4	8	2	2	1	2	12	S035	S027	1	1	1	S000
SI053	3	1	1	1	02/17/11	S005	S018	1	1	2	P02	1	1	2	2	1	1	2	S006	S019	1	6	0	S000
SI054	4	1	1	1	03/01/11	S016	S018	1	1	1	P02	3	3	2	2	1	2	4	S013	S019	1	1	1	S000
SI055	2	1	1	1	03/01/11	S028	S033	2	1	1	P05	5	5	3	3	3	1	20	S054	S032	2	6	1	S028
SI056	4	1	1	1	03/15/11	S034	S033	3	1	1	P02	5	5	3	3	3	2	4	S035	S027	3	1	1	S000
SI057	2	1	1	1	03/20/11	S051	S018	1	6	1	P06	1	7	2	3	1	2	8	S052	S027	1	6	1	S000
SI058	4	1	1	1	04/01/11	S016	S018	1	6	2	P06	7	3	3	2	1	2	8	S013	S027	1	1	2	S000
SI059	3	1	1	1	04/07/11	S053	S018	1	1	2	P06	8	7	2	2	1	2	10	S054	S039	1	6	2	S000
SI060	2	1	1	1	04/10/11	S028	S033	2	1	2	P05	5	5	3	3	3	1	10	S059	S032	2	2	0	S028
SI061	2	1	1	1	04/15/11	S014	S018	1	1	2	P06	8	7	5	5	1	1	8	S015	S039	1	6	0	S000
SI062	3	1	1	1	05/15/11	S005	S018	1	1	2	P02	1	2	2	2	1	2	4	S006	S019	1	6	2	S000

SI063	4	1	1	1	06/01/11	S022	S038	1	6	0	P06	7	8	3	2	1	2	18	S023	S027	1	1	1	S000
SI064	2	1	1	1	07/01/11	S001	S018	1	6	0	P02	2	1	2	2	2	2	4	S002	S019	1	1	2	S003
SI065	5	1	1	1	07/01/11	S041	S018	1	6	0	P05	8	8	2	2	1	1	10	S026	S027	1	1	1	S000
SI066	4	1	1	1	07/01/11	S016	S018	1	1	2	P02	1	1	2	2	1	1	4	S013	S019	1	2	0	S000
SI067	3	1	1	1	07/01/11	S005	S018	1	1	2	P06	1	2	2	2	1	2	4	S006	S019	1	6	0	S000
SI068	4	1	1	1	07/15/11	S043	S033	1	6	0	P05	5	5	3	3	3	1	15	S044	S032	1	1	1	S000
SI069	4	1	1	1	08/01/11	S016	S018	1	1	2	P02	1	1	2	2	1	1	4	S013	S019	1	2	0	S000
SI070	2	1	1	1	09/01/11	S028	S033	2	1	2	P05	5	5	3	3	3	1	8	S069	S032	2	2	0	S028
SI071	4	1	1	1	09/15/11	S043	S018	1	1	1	P06	8	7	2	3	1	2	6	S044	S039	1	6	1	S000
SI072	4	1	1	1	10/05/11	S022	S038	1	6	0	P06	7	8	3	2	1	2	16	S023	S027	1	1	1	S000
SI073	4	1	1	1	10/25/11	S046	S018	1	1	1	P02	1	1	4	4	1	2	10	S047	S019	1	2	0	S000

SI074	3	1	1	1	11/01/11	S020	S033	2	6	0	P05	7	5	3	3	3	1	8	S021	S032	2	1	1	S000
SI075	3	1	1	1	11/15/11	S020	S033	2	6	0	P05	5	5	3	3	3	1	4	S021	S032	2	1	2	S000
SI076	3	1	1	1	11/17/11	S020	S033	2	6	0	P05	5	5	3	3	3	1	4	S021	S032	2	1	2	S000
SI077	1	1	1	1	12/01/11	S028	S018	1	3	0	P03	8	8	2	2	1	1	4	S029	S019	1	1	2	S000
SI078	3	1	1	1	12/15/11	S020	S033	2	6	0	P06	5	5	3	3	3	1	4	S021	S032	2	1	2	S000
SI079	2	1	1	1	01/05/12	S028	S036	2	1	2	P05	5	5	3	3	3	1	6	S078	S027	2	6	2	S028
SI080	1	1	1	1	01/15/12	S028	S018	1	3	0	P03	8	8	2	2	1	1	4	S029	S019	1	1	2	S000
SI081	1	1	1	1	01/20/12	S028	S018	1	3	0	P03	8	8	2	2	1	1	4	S029	S019	1	1	2	S000
SI082	2	1	1	1	02/01/12	S001	S018	1	6	0	P02	1	1	2	2	2	1	2	S002	S019	1	1	2	S003
SI083	1	1	1	1	02/01/12	S017	S018	1	2	0	P02	1	1	2	2	2	1	4	S048	S019	1	1	1	S003
SI084	2	1	1	1	02/07/12	S003	S018	1	1	2	P02	1	1	2	2	1	1	2	S004	S019	1	6	0	S000

SI085	3	1	1	1	02/10/12	S005	S018	1	2	0	P02	1	1	2	2	1	1	4	S006	S019	1	1	1	S000
SI086	4	1	1	1	02/15/12	S016	S018	1	3	1	P02	1	1	2	2	1	1	2	S013	S019	1	1	1	S000
SI087	4	1	1	1	02/15/12	S016	S018	1	1	2	P02	1	1	2	2	1	1	2	S013	S019	1	2	0	S000
SI088	3	1	1	1	02/17/12	S005	S018	1	1	2	P02	1	2	2	2	1	2	2	S006	S019	1	6	0	S000
SI089	2	1	1	1	02/20/12	S049	S038	2	1	1	P06	5	7	3	3	1	2	12	S050	S039	2	6	1	S000
SI090	2	1	1	1	02/25/12	S003	S018	1	1	2	P02	1	1	2	2	1	1	2	S004	S019	1	3	0	S000
SI091	2	1	1	1	03/01/12	S028	S036	2	1	2	P05	5	5	3	3	3	1	4	S090	S037	2	6	2	S028
SI092	2	1	1	1	03/06/12	S028	S033	2	1	2	P05	5	5	3	3	3	1	2	S091	S032	2	6	0	S028
SI093	4	1	1	1	03/15/12	S055	S038	2	6	1	P06	5	7	3	3	1	2	12	S056	S039	2	1	1	S000
SI094	2	1	1	1	03/30/12	S049	S038	2	6	1	P06	5	7	3	3	1	2	4	S050	S039	2	1	1	S000
SI095	2	1	1	1	04/01/12	S036	S036	3	1	1	P05	5	7	3	3	3	2	22	S037	S039	3	6	1	S000

VITA

Paul J. Stamas has over twenty-five years of professional experience leading information technology departments in organizations as diverse as the Department of Defense, General Motors, Sprint-Nextel, Philips Medical Systems, and Albany International. Paul is currently Vice President of Information Technology at Mohawk, a leading manufacturer of premium paper products headquartered in Cohoes, New York USA.

Under Paul's leadership, Mohawk has received a number of highly prestigious awards and recognitions for the innovative use of information technology to deliver business value; to include four consecutive Progressive Manufacturing PM 100 Awards (2008 - 2010), the top (#1) ranked Green IT Organization by Computerworld (2009), Premier CIO 100 Honoree by Computerworld (2010), Mid-Market CIO Technology Innovation Award (2011), and the CIO 100 Award from CIO Magazine (2012).

Paul earned a B.S. in Industrial and Systems Engineering from the State University of New York, a B.A. in Applied Statistics from the State University of New York, an Executive MBA from Rensselaer Polytechnic Institute (RPI), an Executive Masters of Science in Information Management from Syracuse University, and a Doctorate from School of Information Studies at Syracuse University.