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A Virtual Supply Chain System for Improved Information Sharing and Decision Making

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ABSTRACT

Integrated supply chain information systems (ISCIS) face various barriers including lack of alignment between IT and business model, security and privacy concerns, behavioral and cultural issues, and heterogeneous software applications. This paper develops an architecture for ISCIS and validate it by interviewing experts. The proposed architecture is an intermediary to integrate in-house information systems as well as cloud-based systems across distributed heterogeneous supply chain networks. The developed ISCIS architecture works in three layers of data, processes, and knowledge and facilitates the alignment of information systems and decision making with business.

KEYWORDS

Cloud-Based Systems, Heterogeneous Applications, Information Systems Architecture, Integrated Supply Chain Information Systems, Supply Chain Decision Making

INTRODUCTION

To succeed today, businesses need fluid integration of mobile and cloud, partners and suppliers, developers and big data, and security and governance. (Wittmann, 2014, p. 4).

Integrated interorganizational information systems (IS) facilitate supply chain integration (SCI) and improve supply chain decision making (Saeed, Malhotra, & Grover, 2011) which in turn leads to enhanced supply chain performance (Devaraj, Krajewski, & Wei, 2007). However, achieving integrated supply chain information systems (ISCIS) is an extremely challenging task because of the inherent complexity of interorganizational relationships and the volatility of business environment (Choi & Krause, 2006).

The ISCIS challenge is partially due to the heterogeneity of IS that are used across a supply chain. Since no individual business solution can possibly afford to meet all the organization's needs, organizations usually implement several local solutions to augment their core business systems. Many of these local solutions and in-house systems are customized to address specific business purposes. The integration of all these systems is complicated and challenging due to their mismatch. Recently, cloud-computing services became popular and added to the existing mishmash of organizational systems. To maximize the overall effectiveness of intra-organizational systems, organizations rely on integration tools to marry the distributed local and cloud-based systems with the core business systems.

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Organization-wide integration is crucial for business performance (Vallet-Bellmunt & Rivera-Torres, 2013) but is a complicated multi-dimensional task which demands sophisticated integration tools (Williamson, Harrison, & Jordan, 2004). Given the complexity of organization-wide integration, it is obvious that much more sophisticated concepts, frameworks, and tools are required to accomplish such systematic integration across supply chain (SC) members (Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2007; Narasimhan & Nair, 2005). A SC is composed of several organizations with individual and often conflicting goals, and different structures and operations. Integration across SCs must therefore address such concerns as strategic alignment and privacy requirements in a totally different level.

Despite the crucial role of IS in SCI, there is no comprehensive framework available on the ISCIS (Gunasekaran & Ngai, 2004; Palma-Mendoza, Neailey, & Roy, 2014). The authors performed an exhaustive search using different keywords and journals to find previous studies aimed at developing designs and frameworks for ISCIS, but the results showed a gap in this field. The current paper addresses this void by proposing an architecture to combine IT tools and methodologies that are required to achieve SCI. This work is constructed on a successful consulting work that authors did in a holding of 63 companies involved in production, packaging, and distribution of food and beverage products. Given that these semi-autonomous subsidiary companies are poorly inter-connected and have different size, geographical location, and cultures, the holding company triggered an initiative to harmonize SC partners through better-integrated IS. The holding company had previously undertaken several solutions including SAP/R3 in the subsidiary companies to improve collaboration and visibility throughout the chain, but such initiatives failed due to resistance and extent of work. This paper is an outlook on the project “development of a virtual supply chain system” for integration of business processes and IS. The current paper discusses the first layer of the proposed architecture design and does not address further details such as applications, processes, and data flows.

In the next section, the problem and its challenging facets are discussed and the relevant literature is reviewed. In the third section, the available SCI tools are explored and an architecture is developed. The fifth section reviews the measures taken for the validation of the developed architecture. Finally, conclusions are presented in section 6.

SCI AND EXISTING CHALLENGES: LITERATURE REVIEW

The goal of SCM is to enhance overall performance by integrating internal functions of companies and aligning them with that of suppliers, distributors, customers, and other SC players (Kim, 2009). A successful integration should result in a seamless SC with fully-integrated physical, financial, and information flows (Huang, Uppal, & Shi, 2002; Pagell, 2004). Achieving SCI is a formidable endeavor and requires strategic partnership with suppliers, integrated processes, and extensive information sharing with other SC members (Prajogo & Olhager, 2012). Yet SC members operate several internal distributed heterogeneous systems, which exacerbates the integration task across the SC (Li et al., 2010).

IT plays a significant role in SCI. However, despite the importance of IT for SCI, there is a void in studies on design and development of information technologies for SC (Koçoğlu, İmamoğlu, İnce, & Keskin, 2011; X.-H. Lu, Huang, & Heng, 2006; Palma-Mendoza et al., 2014). In particular, the literature needs a comprehensive IT-enabled design or framework to support SCM in business-to-business and e-commerce applications (Palma-Mendoza et al., 2014). In the following, the existing literature on IT architectures and frameworks for SC is discussed and critical considerations to implement SCI are highlighted.

It is well-known that the weakest links within SC identify the chain the most. As a result, local strengthening of individual links does not necessitate escalation of the end-to-end performance (Hausman, 2004). In addition to internal process integration, organizations must realign their processes across SC processes in order to improve the synchronization and responsiveness of the entire chain (Williams, Roh, Tokar, & Swink, 2013). SC processes are, however, highly complex and redesign of them is not a trivial task. Consequently, methodologies are needed to handle this complexity and integrate processes in the enterprise network (Palma-Mendoza et al., 2014). New e-collaboration tools may allow integration of the IS among multiple organizations but tools alone are not sufficient. In order to successfully implement e-business, one should undertake organizational and technological changes together with co-alignment in structures, management processes, strategies, technologies, and individual roles (Palma-Mendoza et al., 2014). Such integration will benefit the entire chain through efficient and effective linkage of various SC activities but is subject to adoption and effective implementation of SCI best practices (Kim, 2009).

The work of Bowersox, Closs, and Stank (1999) is among the first works that has addressed the integration of IS in the SC context. Using empirical research, they present a framework to tackle the critical inter- and intra-organizational integration barriers. Campbell and Sankaran (2005) introduce a framework for evaluation and enhancement of SCI. Alfalla-Luque, Medina-Lopez, and Dey (2013) conduct a comprehensive literature review and present a framework to facilitate SCI where suppliers and customers are integrated around a focal company. There are a few more studies developed to evaluate or improve SCI (e.g. Zhou, Benton, Schilling, & Milligan, 2011). In addition to a these frameworks developed for evaluation of the total SCI, there are a few models that evaluate integration of particular attributes such as quality performance (Lotfi, Sahran, & Mukhtar, 2013), cost performance (Boon-itt, 2009), SC agility (Swafford, Ghosh, & Murthy, 2008), and business performance (Graham, Zailani, & Rajagopal, 2005). Most of this research suggests that ISCIS is the most important element of SCI. Thus, some studies have developed models to evaluate the relationship between IS and SCI (e.g. Gunasekaran & Ngai, 2004).

While there are numerous studies on strategic and operational achievements of SCI, only a few studies have examined the technical complexities of integrating IS across SC (Schubert & Legner, 2011). Some of these studies develop guidelines to select appropriate methods for ISCIS whereas the others propose frameworks for ISCIS. Regarding the methods of ISCIS, some authors discuss the available methods for ISCIS (W. Lu & Zhang, 2011; Themistocleous, Irani, & Love, 2004; Williamson et al., 2004); few authors address the method selection (e.g. Garcıa-Dastugue & Lambert, 2003); and other authors discuss the entire process of ISCIS integration (e.g. Liu, Zhang, & Hu, 2005). Also, there are authors that discuss a specific ISCIS case from different aspects including design and implementation (Bose, Pal, & Ye, 2008; Cheng, Law, Bjornsson, Jones, & Sriram, 2010; Goutsos & Karacapilidis, 2004; Li et al., 2010; Lo, Hong, & Jeng, 2008; Tarantilis, Kiranoudis, & Theodorakopoulos, 2008). Regarding the frameworks for ISCIS, these frameworks serve the purpose of analysis, design, and implementation of ISCIS and discuss various aspects of inter-organizational integration from different perspectives (Humphreys, Lai, & Sculli, 2001; Jung, Kim, & Kang, 2006; Schubert & Legner, 2011; Wolfert, Verdouw, Verloop, & Beulens, 2010).

Despite the scholarly work and the available body of knowledge regarding ISCIS, organizations still fail to implement ISCIS and few companies have truly engaged in and accomplished such extensive integrations (Deshpande, 2012; Jayaram & Tan, 2010). While there are numerous reasons for dearth of ISCIS, the lack of a holistic design and framework towards SCI is a central drawback. Both research and practice acknowledge that there are major barriers that prevent from accomplishing the ISCIS (Gunasekaran & Ngai, 2004; Harland, Caldwell, Powell, & Zheng, 2007). These barriers are categorized and summarized in Table 1 (See Appendix). The extent of literature presented in previous paragraphs fails to address these barriers and concerns. Therefore, this paper focuses on these concerns and barriers and elaborate its research questions based on them to address this void in the literature.

This paper designs the architecture for SCI from IS perspective. By developing architecture for ISCIS, authors aim to improve the alignment between IT and business processes of SCs, tackle complexity issues in ISCIS, address behavioral and cultural factors, elevate trust among SC members, and improve SC decision making practices. Therefore, this paper argues that a successful ISCIS must address the concerns specified in Table 1. The developed framework for SCI must therefore be able to answer the following major research questions:

- What is the best IS architecture for SCI?
- What is the best IS architecture for supply chain knowledge creation?
- How does the design integrate heterogeneous intra and inter-organizational systems?

ARCHITECTURE FOR INTEGRATED INFORMATION SYSTEMS

To develop an integrated architecture for heterogeneous IS applications in SC members, authors first present a model for SC processes and data transactions. To integrate the presented model with ISCIS, three alternatives to information system architectures are presented and their appropriateness is evaluated. Authors then select one of the alternatives which best suits heterogeneous systems integration. The selected architecture is further developed to accommodate cloud-based systems as well as inter- and intra-organizational systems. A conceptual design is presented for integration architecture in form of a virtual SC system, and its functionalities are discussed. Finally, authors validate the developed design and its applicability by presenting the architecture to several experts.

SUPPLY CHAIN PROCESSES AND DATA TRANSACTIONS

In addition to fundamental intra-organizational functions, every company handles a set of inter-organizational transactions with the other SC members. In the supply chain operations reference (SCOR) model, these functions and transactions are described as constituents of SC processes. By integrating work and data flows across SC entities, one can describe the elements required to integrate SC business processes. These elements include data and document exchange for shared processes and coordinated activities. Figure 1 (see Appendix) depicts basic processes and data transactions which exist in a typical SC.

IS interact with both intra- and inter-organizational business processes. To handle business operations, SC members employ a wide array of IS (Helo & Szekely, 2005). In large enterprises, the number of application systems, that should ideally be interoperable, easily reaches thousands (W. Lu & Zhang, 2011). These IS could be standalone or on a local network, developed in-house or through third parties, installed and stored on internal servers or on clouds, and used exclusively by a single member or shared among several organizations. The vast variety of IS' features used within a single company demonstrates that integration of IS across SC is a daunting task.

Figure 1 shows significant overlap in application service functionality. This necessitates mutual data transaction for all members so that they can perform in a reconciled fashion (Helo & Szekely, 2005). Digital platforms are key infrastructures for effective execution of SC activities and managing partnerships (Rai, Patnayakuni, & Seth, 2006). However, success of the IOIS does not depend on the technology only; intensive stimulation, shared vision, cross-organizational implementation teams, close integration with internal IS, inter-organizational business process re-engineering, advanced legacy information system, and infrastructure and shared industry standards are required to guarantee the success of ISCIS (X.-H. Lu et al., 2006; Rajaguru & Matanda, 2013).

SUPPLY CHAIN INFORMATION SYSTEM ARCHITECTURE

There are various architectures for IS across SC. Some of these architectures are intended to integrate ERPs while others are developed for integration of heterogeneous IS (Kobayashi, Tamaki, & Komoda, 2003; Themistocleous et al., 2004). Schubert and Legner (2011) developed and compared five different scenarios of B2B integration within SC. This study focuses on three major architectural scenarios that are most frequently addressed in the literature. These include (1) Direct partner integration, (2) Heterogeneous systems connected to intermediaries, and (3) Global ERP: a centralized ERP for all SC members. Figure 2 (see Appendix) depicts a schematic view of the three scenarios.

In order to decide on an appropriate ERP configuration, one should consider that there are basically two different SC topologies: (1) SCs with domination of one firm over the others, and (2) Cooperative firms across the network (Verwijmeren, 2004). Global ERP fits the former type of SC topology (dominating firm), and heterogeneous systems is practical for the latter (cooperative firms). Apart from technological intricacies of implementing global ERPs and the associated philosophical questions that arise (e.g., the cross-connectivity of all SCs requires a singular global ERP connecting all firms), there are basically other motivations to implement distributed ERPs.

Global ERP is Less Effective

Although ERPs are useful tools for SCI, the global ERP lacks autonomy and flexibility required by network organizations. In addition, since SCs need to be coordinated without sacrificing their flexibility, rigid automation for the whole chain may not be accomplished when global ERP is in place (Verwijmeren, 2004).

Heterogeneous Systems Connected to Intermediary Better Supports the Perceived Need

Yanhuia and Xiana (2012) argue that integration of SCs under grid environment (heterogeneous distributed IS) is more operational-efficient. The distributed information system supports the autonomy of each SC member which results in higher flexibility, more agility, and higher levels of information security. In addition, the implementation of such systems is less painful due to lower levels of complexity and resistance, and support for multi-cultural environments.

Direct Partner Integration Works When There are Fewer Number of SC Members

Considering the use of extended ERP by two SC members, such systems can integrate with supplier relationship management (SRM), customer relationship management (CRM), transaction management foundation, e-procurement and e-commerce. Extended ERP better supports the integration of SC players, and internet and extranet systems provide the necessary platform for improved communication (Gunasekaran & Ngai, 2005; Møller, 2005). One must note that communication between customer's SRM and supplier's CRM is not trivial to implement. Implementation of ERP solution is complex and exhaustive, and its success depends on how well the entire process is managed and executed (Sheu, Chae, & Yang, 2004). In addition, when the number of SC members increases, integrating the chain using direct connections becomes highly complicated.

Therefore, the second configuration (heterogeneous systems connected to intermediaries) is plausible and preferred over the other two configurations. This configuration works well for distributed SCs lacking a major SC player. In the case of the holding company that authors worked on, authors also deployed this architecture but there might be cases where, due to specific circumstances, other scenarios work better.

Integration of Cloud Services

Cloud computing service provision is a new trend in both technical and business development (Li et al., 2013). Several cloud computing solutions such as Salesforce cloud products, Cisco cloud computing, and Amazon and IBM cloud have been successfully implemented to date. Since cloud-based solutions cannot fully address all business requirements of organizations, a conglomeration of multiple clouds and local systems are typically used. In the realm of cloud computing, there are platforms that provide opportunity for integration of various private clouds and local systems: AtomSphere, Cast Iron Omni Connect, and Amazon SQS are a few examples of such platforms. These services have their own pros and cons, such as restrictions for further development or flexibility of user-interface. Until today, several platforms for integration of clouds have been introduced with extensive business applications. However, there is a dearth of empirical research on the integration of clouds. Li et al. (2013) discuss the challenges and requirements of multi-cloud computing and propose a model-based architecture to achieve multi-cloud integration. Applying the architecture of Li et al. (2013) into SC, Figure 3 (see Appendix) presents the configuration of multi-cloud integration platform in SC context.

Integrating cloud systems and information silos with enterprise systems requires especial attention due to different nature of clouds. First, clouds use specific standards (e.g. http) to communicate with other applications. Second, since there are many cloud service providers, the diversity of systems has increased. This diversity ranges from privacy policies and security considerations to database, engine and internal processes. Thus, the integration of cloud and enterprise systems is challenging per se.

Design of Integrated Information Systems for Supply Chain

Figure 4 (see Appendix) shows the configuration of SC integration platform constructed on the proposed ISCIS and cloud architecture. In this design architecture, ERP systems are distributed. A central virtual SC system manages the relationship between enterprises systems, ERP-systems, and clouds.

Inter-organizational systems must allow the automated flow of information among individual organizations (Hong, 2002). Local systems could be simply linked by electronic data interchange (EDI) which inherently provides higher SC visibility. EDI, however, does not accommodate SC decision support tools (Verwijmeren, 2004). SCI requires a data interchange platform that supports decision making tools with appropriate security and privacy levels.

Virtual SC system is an inter-organizational integrated enterprise application that is composed of several layers including data, process, knowledge, and application layers (Themistocleous, Mantzana, & Morabito, 2009). Within the data layer, connection, transportation, and translation take place. Translation converts all input into a common format that can be efficiently stored and effectively processed. Within the process layer, processes are integrated. This is the stage where communication occurs through integrated work flows. All output must be rendered in formats that are comprehensible by target applications. Malhotra, Gosain, and Sawy (2005) suggest that flow of information among SC members results in SC knowledge creation. Therefore, the third layer is the knowledge layer where knowledge is created, integrated, and managed. In this layer, data from the data layer is converted to knowledge through employment of business intelligence and analytics tools. The developed knowledge is required for management of process layer and decision making within SC. This knowledge is integrated with prior explicit knowledge of organization and managed using knowledge management tools. A schematic of layers within virtual SC system that is developed based on Helo and Szekely (2005) and Themistocleous et al. (2009) is depicted in Figure 5 (see Appendix).

Table 2 (see Appendix) shows how the developed architecture answers the ISCIS concerns that are presented in Table 1. A critical privilege of the developed architecture is that the final design respects the existing flexibility of each SC member. The developed architecture provides each member with unique integrative properties so that they remain coherent across SC while continuing on their existing overall course (Morash & Clinton, 1998).

Also, the developed architecture can answer the research questions. The proposed architecture, since it does supports most of concerns discussed in Table 1, supports SCI. The layered design enables knowledge creation and management through access to operational needs and shared data. The layered concurrent structure supports the use of intelligence and analytics for process improvement. The data and analytical tools could also be used in decision making at other layers of supply chain. Finally, the developed architecture does not use ERP or other systems as its core. Instead, it creates a virtual that allows SC members to maintain their existing systems. The proposed architecture enables SCI with minimal changes in inter- and intra-organizational processes.

EMPIRICAL VALIDATION

In previous section, authors relied on the existing literature to propose three scenarios for B2B integration within SC, and designed the architecture for integration of heterogeneous SC systems accordingly. Since authors used a non-empirical, prescriptive method to develop the design of this architecture, in this section, authors validate the results to ensure that the architecture meets the design objectives. IEEE standard defines validation as "the process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements" (Radatz, Geraci, & Katki, 1990). Frey and Dym (2006) argue that validation is necessary to guide the development and evaluation of new designs. Olewnik and Lewis (2005) argue that the validation of prescriptive designs is more complicated because subjective elements are used in the validation process. They conclude that three major criteria must be considered in the validation process: (1) design must be logical; (2) it must use meaningful, reliable information; and (3) the employed method should not bias the designer (researcher). In the situations where the design is too complex to be validated by the available knowledge, the existence of correlation between the design and reality (simply using best-to-date logic) constitutes a foundation for model validation (Todd & Gigerenzer, 2003).

Given that the proposed design is prescriptive in nature, authors validate the model by bouncing it against reality, that is, presenting it to experts in interview sessions. To this aim, authors initially selected 16 experts but later managed to coordinate with 12 of them for face-to-face interview or video conference calls. These experts were working in different fields including enterprise architecture (4), system design and architecture (2), system analysis (2), database management (2), security (1), and network architecture (1). Since presented architecture is developed for heterogeneous systems, authors strove to contact experts that had experience with such systems. Executives in holding companies and consultants constitute the two groups of experts that were interviewed. The executives were selected from 3 holdings engaged in extensive SCs. The two system architect experts and one of the system analysts were selected from a consulting company active in the field of enterprise architecture. The rest of them are from IT-based companies that provide services to big holding companies. These holding companies are the major owners of the SCs of various products, from raw material to manufacturing, packaging, marketing, sales and distribution. Although they are not active in operation, they manage the integration of their own subsidiaries across SCs. Therefore, authors consider holding companies as good fits for the validation. The cooperation of these experts was made possible due to authors' connection with the CIO's of these three holdings and the CEOs of the consulting companies. C-level managers introduced experts (all in high- or mid-level managerial positions) with related experience and vast knowledge about ISCIS. In case of the holdings, some experts are serving in headquarters and some are in the IT departments of either the holding or subsidiary companies. All experts have at least 10 years of experience in related business.

The interviews were conducted in two-steps. In the first step, interviewees received a two-page description of the developed architecture. Authors gave them 3 days to consider the architecture carefully and map its applicability in their own business cases. In the 4th day, a semi-structured interview meeting was held. The interviewees were asked to challenge the design and propose corrections/improvements. Furthermore, they were asked to describe the advantages and disadvantages of implementing the proposed design in their SC business cases. At the end of the interview, their implementation concerns were discussed. The key findings of the interviews are presented in the following. These findings are consistent with the findings and discussions of Schubert and Legner (2011) regarding B2B integration scenarios.

Appropriateness of the Proposed Architecture

Interviewees unanimously asserted that the developed architecture can work in their business environment and well responds to the SC integration needs. The SCs that are composed of distributed heterogeneous IS will benefit from the proposed design the most. However, in cases where companies with identical information system platforms can directly integrate with one another, the proposed architecture results in higher complexity as well as delay in integration, and so is not the preferred solution. In other words, the proposed architecture best works in complicated SC networks. In case of simple chains, other integration methods are more appropriate to implement.

Advantages

The interviewees mainly concur on the ease of implementation. In fact, the superiority of the architecture lies in its ease of implementation. The designed architecture allows SC members to retain their existing IS. Since the proposed architecture does not affect the existing internal systems and processes of organizations, the implementation phase is relatively short. In addition, challenges such as resistance to change are minimized. Also, by selling data and knowledge, the system may generate a new source of revenue for SC members.

Disadvantages

Most of the experts consider the delay in synchronization of data as a system disadvantage. The other disadvantage mentioned by interviewees is data redundancy. The proposed design needs to collect and store duplicated data in distributed data warehouse.

Concerns

All interviewees expressed their concerns about data security and the subsequent risks imposed to the SC. There were also concerns associated with data ownership and the sharing of the relevant costs and benefits. The essence of commitment and support from top-level management was highlighted. Also, the system must be embraced by all SC members; otherwise, there will be a breach in information flow and the system will not meet its expected goal. Strategic integration is also an important aspect of this integration. Misleading and biased reports as well as poor performance of knowledge creation and usage are two consequences of the absence of strategic integration.

Suggestions

These comments and suggestions from the interviewees do not question the underlying of the proposed architecture but provide remarks to improve the development process as well as the practice of ISCIS. The most important suggestions are summarized as follows: (1) successful implementation requires well-designed policies and regulation; (2) there is a need for improved standardization for communication between systems and software suppliers, and cloud services should provide the standard data exchange format; and (3) the system must basically be a cloud service for SC members, and should be managed by a professional independent team.

These results validate the virtual SC system of Figure 4 and its architecture in Figure 5. Furthermore, they reinforce the contents of Table 2 on how the proposed architecture addresses the well-known ISCIS concerns and questions. Successful implementation of the proposed architecture in a SC in food and beverage industry augments the validity and applicability of the proposed ISCIS architecture.

CONCLUSION

For most practitioners and researchers, comprehensive SCI is more a rhetoric than a reality. This paper targets the development of a design architecture that improves integration across SC. Given that there is limited study on ISCIS architecture, authors combined a set of methods and tools including SCOR model to develop such architecture. The proposed architecture helps to develop an IT infrastructure both within enterprise and across the SC while retaining the existing flexibility of each SC member. The developed architecture provides plausible answers to questions and criticisms that authors faced in the SCI literature. Also, it enables IT-business alignment (Kappelman, McLean, Johnson, & Torres,

2016) and facilitates knowledge management process through improved access to data, ability to incorporate business intelligence and analytics across business processes.

The motivation for this work came from a successful consulting service that authors provided to a holding of 63 companies in food and beverage industry. The implementation phase was relatively simple and did not require extensive investments. In addition, it did not result in cultural resistance; a major issue that had caused failure to the previous attempts to integrate their IS application in SC. Authors observed drastic improvements in SC visibility, improved planning and control, and reduction of waste and rework. Authors constructed this paper on a successful consulting work but developed the ISCIS architecture from the perspective of a generic SC. To validate the ISCIS architecture, authors interviewed experts and the results supported the validity of the proposed architecture.

While this paper addresses a void in SC literature, it raises several new questions for SC researchers to answer. Among all, the impact of this integration on relationships with suppliers and customers, overall business performance improvement, and improvement of planning capability is difficult to measure and analyze. This difficulty is driven by the fact that although the repercussions of integration reaches all members of SC, collecting data from individual SC members to measure the overall improvement is not a trivial task. It is also a challenging task to regulate knowledge ownership much less data ownership policies across the SC. Questions such as how to protect and share the created knowledge, how to improve strategic alignment of SC members, how to standardize integration interfaces, and how to design standardized integration architecture remain to be answered. Finally, the future ISCIS will be impacted by the explosion of data and radical shifts in IT technologies, and the opportunities and threats that will grow around these changes remain as interesting topics that must be addressed by future studies.

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APPENDIX

Table 1. Key Concerns in Developing ISCIS

Category	Key concern	Barriers
Strategic and organizational factors	Alignment with intra-organizational systems and strategic plans	• Lack of alignment between IT and business model • Misaligned goals and diverge objectives • Short-term focus rather than long-term commitment • Lack of strategic focus in supply chain decision supports
	Security and privacy	• Lack of trust and awareness, fear of losing control
	Cultural impeders	• Behavioral and cultural factors
Tactical and executional factors	Extending integration across SC	• Independent IS • Organizational arrangements and structures imposed on employees • General SC complexity issues
	Information sharing	• Lack of standardization on data and systems • Information distortion • Integrated and aligned decision making
	Implementation	• Poor IT infrastructure • Insufficient application of IT in virtual enterprise • Inadequate knowledge of implementing IT in SCM

Table 2. Developed Architecture Addresses Questions and Meets Concerns

ISCIS concerns	*How addressed in the proposed architecture*
Alignment with intra-organizational systems and strategic plans	Intra-organization changes are minimized and each company continues its existing course whereas the architecture improves coordination and visibility across SC. It also increases alignment of members' strategies with the SC strategy. For new SC partners, it is easier to connect and share with other SC members.
Security & privacy	Companies merely share supply and order data and information. No need to share information on internal functions. A security and data ownership policy manages the information sharing and communication in the SC.
Cultural impeders	The intra-organizations processes, systems, and functions remain almost intact unless reengineering of internal processes is considered. Therefore, low cultural resistance is experienced.
Extending integration across SC	The architecture provides the required tools for intra- and inter-organizational integration. Therefore, software development is minimized by practicing restricted information sharing and reporting.
Information sharing	Only authorized members of SC may access restricted information.
Implementation	No intra-organizational transformation. Minimal resistance, cost effectiveness, and short implementation. The primary burden is on the SC manager to implement the virtual system.

Figure 1. Processes and Data Transactions Within SC

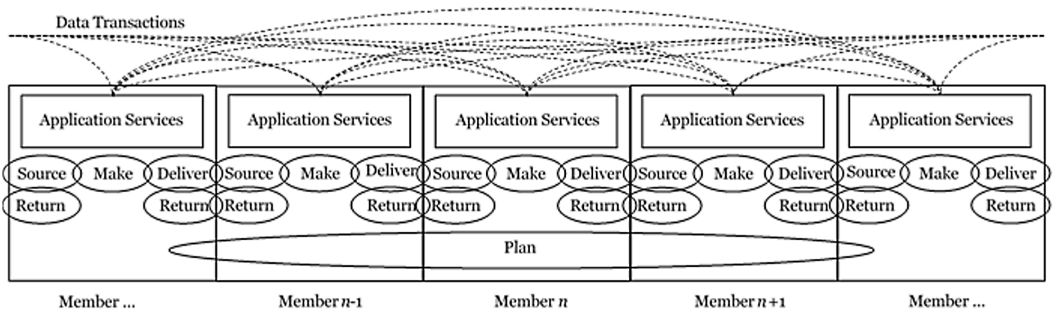


Figure 2. Direct Partner Integration (top); Heterogeneous Systems Connected to Intermediaries (middle); Global ERP: A Comprehensive Solution for Global Chains (bottom) (Schubert & Legner, 2011)

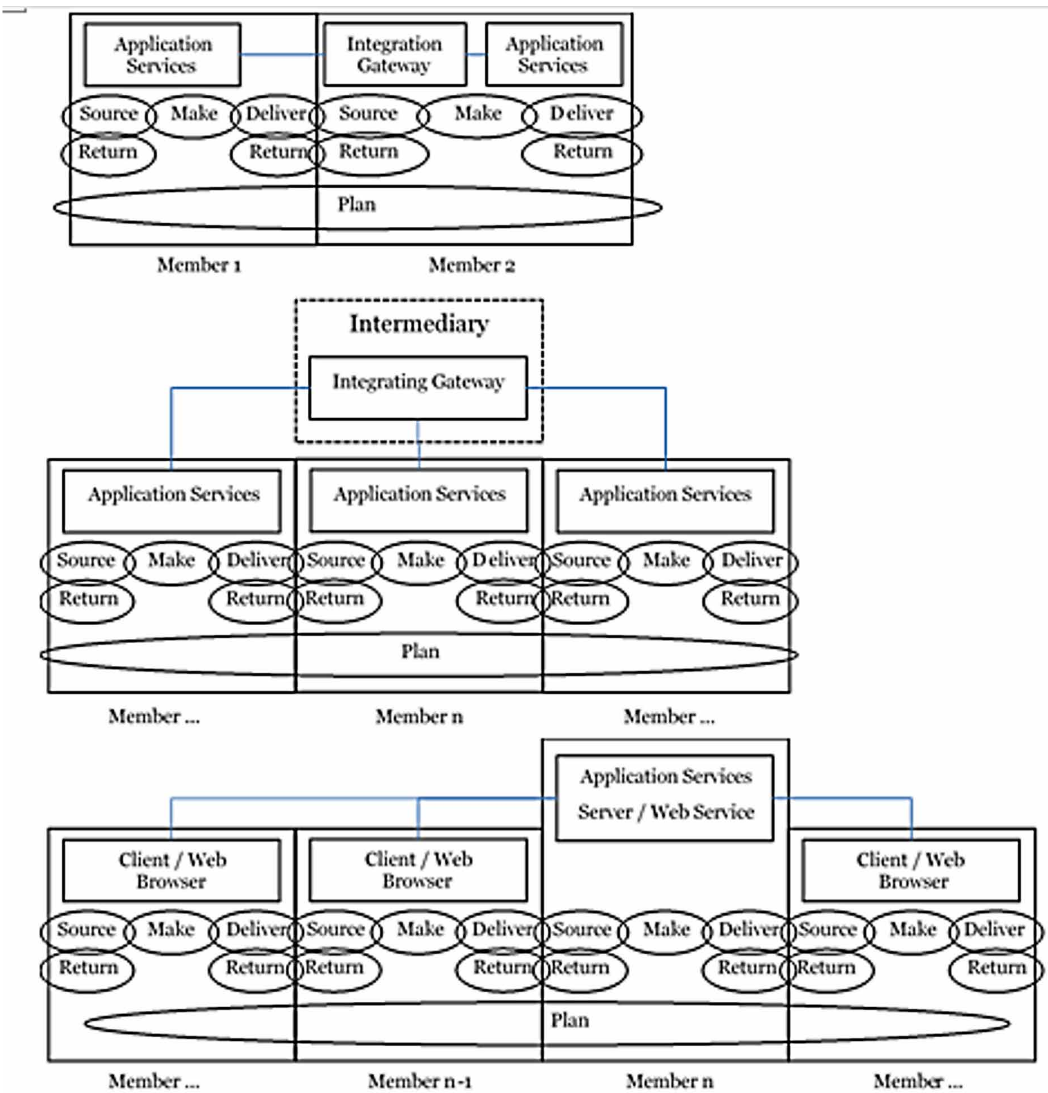


Figure 3. Multi-Cloud Integration Platform for SC. Enterprises Use Various Clouds Per Their Business Practice. Multi-Cloud Integration Platform Acts as an Intermediary in Collecting and Sharing Data and Information

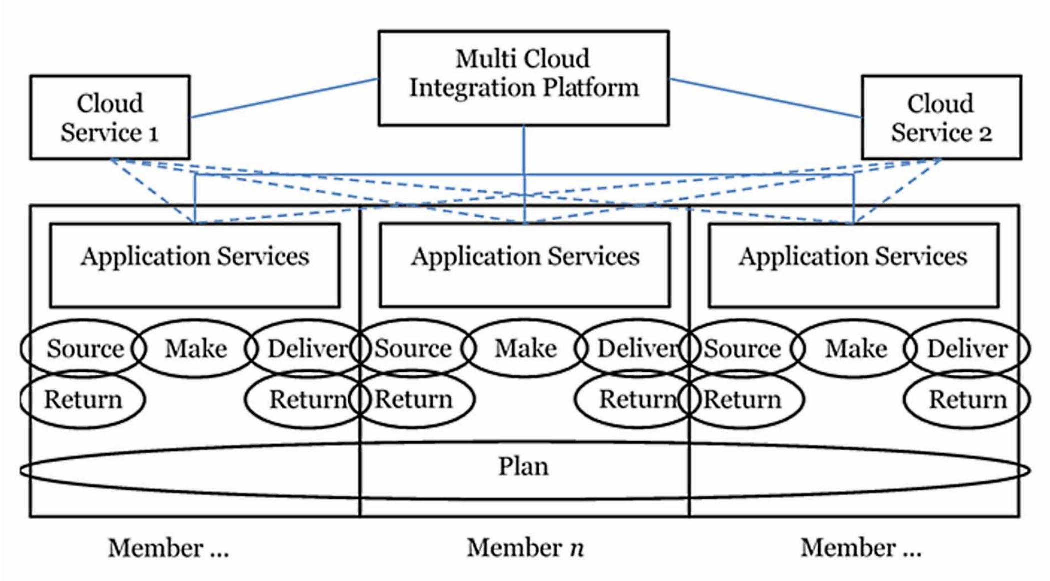


Figure 4. Virtual SC System for Integration of In-House, ERP, Enterprise, and Cloud-Based Systems

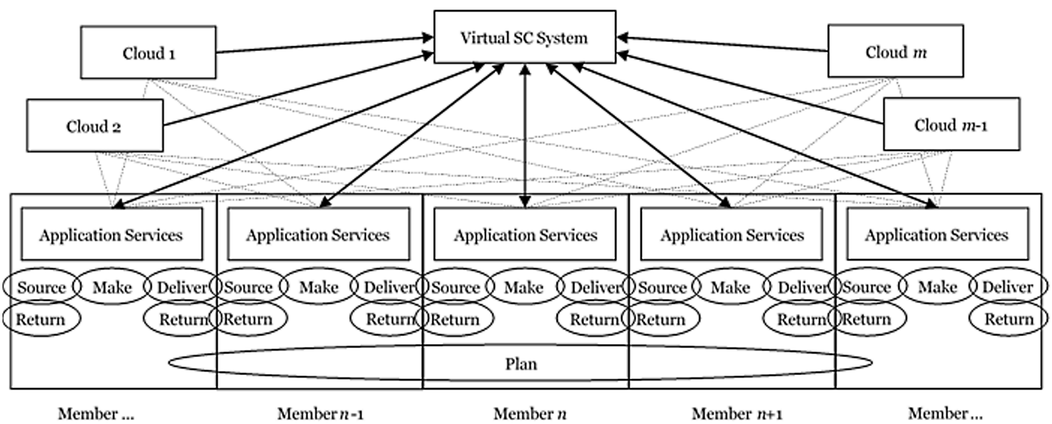
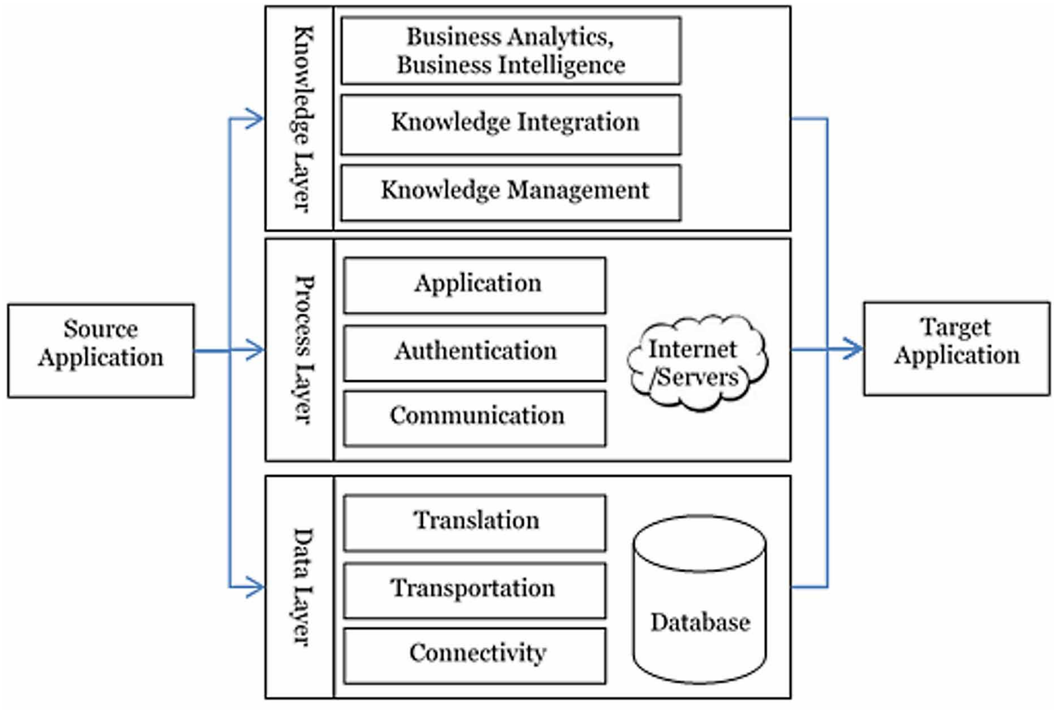


Figure 5. Virtual SC System Architecture



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