Challenges of Business Process Modeling in Logistics and Supply Chain Management

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Summary
In the domain of Supply Chain Management (SCM), business process should be structured in a flexible manner to allow full use of supply chain information. To investigate the characteristics and importance as well as the limitations in supply chain process modeling, in this research, six main frameworks and references models including SCOR, GSCF,VRM,CPFR, ISA95, and SAP are compared and discussed. Finally, the state of the art and challenges in several current methodologies in supply chain process modeling are discussed. The results show that the main challenges with respect to the modeling methodologies is to extend them for supporting different stages in the development of supply chain information systems.

Key-words:
Logistics, Supply chain process, Process modeling, SOA, Modeling Language

1. Introduction

According to Lambert and Cooper [1], the supply chain is not a chain of B2B relationships but a network of several businesses. The management of the relationship in this network is referred to as SCM. In the concept of SCM, a supply chain is defined as a chain of organization which involves, through a linked set of upstream and downstream, the diverse activities and processes that produce value in the form of services and products for the end customers [2].

Numerous studies, related to SCM, have been conducted both in optimizing supply chain in order to improve customer service [3], increase flexibility [4], and reduce operating cost [5]. Accordingly, many studies have discussed the influence of information sharing on supply chain integration. However, most of the problems are caused by demand uncertainty or inability to coordinate many different activities and supply chain partners[6]. Therefore, improving supply chain performance requires integration with both business process and information sharing[7], and coordinating activities related to the main three flows (that is, information flow, material flow, and financial flow) [8]. As a consequence of complicated interactions in the supply chain which involves multiple enterprises and relevant resources, the operations of the supply chain participants should be effectively aligned to reduce the total expense and enhance the level of customer service [9]. The coordination of operations in SCM is the major purpose of SCM, which necessitates modeling and integrating processes. The number of decisions which are to be executed and the amount of data which is to be processed or exchanged entails the construction of an accelerated information system that can support the flexibility of handling unexpected changes and events in the supply chain process [10]. Hence, business process should be structured in a flexible manner to allow full use of supply chain information [11] and to organize the activities among supply chain participants [4]. To consider business process entails laying emphasis on process models as the core object for the attainment of the necessary agility and interoperability of information systems (Verdouw & Wolfert 2010) which can be addressed by SOA as a fast growing paradigm in IT, widely applied in SCM and enterprise information systems [12]. SOA makes possible the dynamic reconfiguration of supply chains, enabling them to readily adapt themselves to the changes within business models and to the soaring globalization and increasing coordination. The adoption of SOA paradigm is accrued by the conversion of information systems and data sources into modular service components, which can be designated, pinpointed, and invoked by other applications, be means of a standard protocol. Multiple applications in SCM reuse the service components [13].

The second section discusses the existing supply chain frameworks and reference models including SCOR, GSCF, VRM, CPFR, ISA95, and SAP. This review identifies the limitation of current supply chain reference models and pinpoints what is needed to support an IT-based Supply Chain Processes. The third section discusses the underlying concepts of SOA in terms of enterprise business process. Section four provides an overview of business process modeling with an emphasis on modeling techniques. The fifth section compared and discussed several most important methodologies for supply chain process modeling. Finally, the last section summarized the paper with guidelines and recommendations for further research works.

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2. SUPPLY CHAIN REFERENCE MODELS

This section provides an overview of existing SC reference models and frameworks, which have been broadly applied in the past years in the domain of SCM. The reference models are used for the designing and development of software components; they also support different stages in the development of information systems, including requirement engineering, design, and implementation [14]. In the development of information systems, process models are the first and essential artifacts that are concerned with the requirement documentation and communication to stakeholders [15]. In the first stage, requirements should be defined via modeling business process [16]. In the domain of supply chain, the reference models and frameworks which support different stages of information system development consist Supply Chain Operation Reference (SCOR) [17], Global Supply Chain Forum (GSCF) [18], Value Reference Model (VRM) [19], Collaborative planning and Forecasting & Replenishment (CPFR)[20], International Society of Automation (ISA-95) [21], and System and Application Products reference model (SAP)[22].

Supply Chain Operation Reference (SCOR) model has been developed by the Council of Supply Chain Management in 2005 as a cross-industry to represent business activities and processes of the supply chain that can be used in the requirement stage of IS development [14]. SCOR includes five business processes: Plan, Source, Make, Deliver, and Return. However, SCOR does not provide mechanism for process specification level in details [23]. As a result, SCOR does not have the potential to specify process-services in SOA. Moreover, SCOR focuses on production strategy rather than on SCM strategy [24].

Global Supply Chain Forum (GSCF) is a supply chain framework founded upon eight key business processes in which each business process is managed by a cross-functional team, including representatives from logistics, production, purchasing, finance, marketing, and R&D [18]. GSCF framework is cross-firm and cross-functional which deals with production, R&D, logistics, marketing, purchasing and finance[14, 18]. It defines the corporate strategy in SCM and links the strategy to the business processes [18], and supports the requirement stage of IS development [25].

Value-Chain Group developed the Value Reference Model (VRM), which similar to SCOR, is used to specify supply chain processes in Strategic, Tactical, and Operational levels [6]. It contains process models and metrics, focusing on planning, governing and execution of activities for logistics, product development, and commercial processes [19, 25]. Further, VRM supports requirement stage in IS development and it is integrated with SOA based on Federated Enterprise Reference Architecture (FERA) [14]. However, VRM is limited to information flow and the value of the information [26]. Moreover, VRM does not support key supply chain processes and activities, for instance, it does not include Return Management Process [27].

CPFR provides a general framework, focusing on Demand & Supply Management, Strategy & Planning, and Execution and Analysis. The framework contains process and data models that can support design stage of IS development [25]. Nevertheless, the framework does not identify major business processes in SCM; it addresses, in fact, four supply chain processes including supplier-managed inventory, conventional order management, co-managed inventory and retail Vendor Managed Inventory (VMI)[25]. Further, the primary focus of CPFR is the relationship between buyer and supplier [28].

International Society of Automation (ISA-95) addresses the exchange of data within enterprise systems (planning, and production management systems) [29], including a number of components such as manufacturing operations & control, and business planning & logistics [14]. It can be used in the design stage of IS development [25], but the scope of ISA standard is limited to describing the function, the domain and control of an enterprise [29].

System and Application Products (SAP) Production Solution Center developed SAP-ERP to support process and application in SCM [30] that could support implementation stage of IS development [14]. SAP/R3 cannot address every perspective for supporting entire supply chain processes, for example, the relationship between suppliers (SRM) [30]. Moreover, SAP is primarily focused on implementation of ERP and consolidates very detailed system models in which the models are focused on one single enterprise [25].

An overview of the aforementioned reference models is summarized in Table 1 This table show the extent to which these reference models meet the IS development and scope of SCM. From the viewpoint of IS development, only reference models, namely SCOR, GSCF, and VRM, which support the requirement stage by prescribing the decomposition level of supply chain processes.

Table 1 : Overview of SCM reference models

Reference model	Stage of IS development	Scope of SCM
SCOR	Requirement	- Operation strategy - Transactional activities related to demand, supply, sourcing, planning, distribution & reverse logistic - SCM strategy
GSCF	Requirement	- Key activities related to the successful implementation of macro-business process in SCM [18]
VRM	Requirement	- Activities related to product development, logistic, planning & control, and supplier relations [19]
CPFR	Design	- Activities related to order management, supplier-managed inventory & Vendor Managed Inventory (VMI) - Strategic activities focusing on forecasting and replenishment process[20]
ISA-95	Implementation	- Function related to business planning & logistic, and manufacturing operation & control [21]
SAP	Implementation	- Process related to logistic, production & manufacturing focusing on 'make-to-order' and 'engineer-to-order' [22, 30]

Table 1 states SAP and ISA95 support implementation stage of IS development and CPFR supports IS development in the design stage. Since business process modeling belongs to the requirement stage, none of reference models, support both the coordination and interaction of process models in the lower level [6, 18] nor service-oriented approach in supply chain process modeling. Of the two reference models SCOR and GSCF, which have been widely used in production and SCM, SCOR meets operation strategy while GSCF meets SCM strategy. SCOR focuses on specific activities in SCM and GSCF focuses on the relationship between suppliers and customers; but both of them neither can describe supply chain processes from different views nor address the inter- and intra- organization processes in details [31].

3. SERVICE-ORIENTED APPROACH

The traditional way of providing new applications for organizations was to purchase them from software providers and then they customized or modified them in order to develop the applicability of the purchased applications. The adoption of the above approach is costly and it often results in the production of new applications which do not yield easily to further modifications [32], particularly in SCM. There are numerous tiers within a modern supply chain, ranging from suppliers to manufacturers, distributors, retailers, and customers. A well-defined architectural style is required for building web-based IS for SCM. However, the existing architectural styles, for example, Enterprise Application Integration (EAI) approaches and Object-oriented Architecture, do not have adequate capability to produce a flexible IT-architecture which is able enough to adapt itself to the ever-increasing pace of business needs [33]. This problem can be addressed by SOA, as a fast growing paradigm for designing a flexible enterprise IS to enhance agility [12, 34, 35].

SOA, in comparison with the existing architectures and approaches, initially permits business partners to share their internal information by incorporating the acquired data into individual service units, which are available across the network. SOA-based systems perform two tasks: (1) they allow the transference of information along the enterprise boundaries;(2) they make possible the implementation of various applications through those service components that increase the ease of, and flexibility for, supply chain reconfiguration [13]. SOA makes possible the reuse of services within an organization, aimed to support diverse business applications. Services Infrastructure, methods, and instruments are to be defined in SOA in order to incorporate services into broader business process [33]. To this end, business architecture must be able to provide a inclusive definition for the entire scope of service landscape. Business architectures define service groups to support business process and have effects on business strategies and goals [33]. To create meaningful services and to define the specific features of a business process in service-oriented paradigm require the consideration of a method which has a higher potential for business alignment. Such a method is required to deal with the analysis and design of services as well as with the techniques and methodologies [36]. Therefore, in the representation of supply chain processes in service-oriented approach, modeling relationship between processes and services' view must be clear.

Regarding to what has been discussed, during the creation of an IT-based business process for SCM, it is required to initially analyze the business domains and process areas of the given enterprise. Next, it is necessary to model the

business processes, which are to be supported by the SOA. Eventually, the process models have to be converted into service orchestration description. Hence, in this approach, business process modeling plays an important role, which is also an essential step in developing information system for SCM[6]. In this regard, the next section discusses about the interplay between BPM and business process modeling emphasizing on modeling techniques to supply chain process modeling.

4. BUSINESS PROCESS MODELING

An effective and integrated SCM requires Business Process Management (BPM) life cycle from modeling to implementing and monitoring of supply chain processes [9]. In this regard, BPM is a specific filed including concepts, methods, techniques and tools to design and analysis, implementation, and enactment of business processes [37]. Industrial engineers apply BPM in organizations as an optimization technique. In order to execute and monitor business process, IT specialists consider it to provide a shared language for communicating with business managers and process analysts, and industrial engineers [15].

Modeling supply chain process in service-oriented approach requires both service specification and business process configuration as sequence of services [6]. To do so, it is needed to depict the internal activities of an organization, and interaction between business partners, which are known as process choreography and service orchestration [38]. A flexible execution of SCM based on SOA requires process model in high quality of syntactical and semantic formats, particularly in the sequence of activities, events, information flow, and control decision [39, 40]. Therefor, a proper modeling language must be selected to represent a conceptual model of business processes [38]. Furthermore, it is worth mentioning that the properties of the real world and the interactions among its constructs and components have to be considered as the basis for modeling languages. Thus the significance of the process model should be based on underlying modeling techniques [41]. It is worth mentioning that the properties of the real world and the interactions among its constructs and components have to be considered as the basis for modeling languages which are used in information system models [42].

4.1 Modeling Languages

Regarding modeling techniques, a plethora of Business Process Modeling Languages (BPMLs) have been applied in order to develop enterprise information systems. Many of these techniques were developed for different purposes such as system analysis and design, database design, software engineering, and coordination theory [43]. Traditional modeling techniques came from works on Management Information System (MIS) and business process engineering [44]. However, according to Curtis et al (1992), information system modeling has focused on analyzing an organization's data. Therefore, object oriented modeling languages were later adopted for modeling enterprises. Furthermore, object oriented modeling languages are recognized as a paradigm for enterprise modeling which adds value to an analyst and designer [45]. During the last decade, enterprises have been faced with the challenge of continuously adapting to changes. Each enterprise has its own process and different process models have to be integrated in the business environment [9] .[44] found eight modeling techniques including Petri nets, IDEF, EPC, UML, BPMN, WS-BPEL, and ebXML to be the most popular modeling languages which have been widely applied in industrial and enterprise modeling. This study will concentrate on these eight modeling techniques.

5. Comparison of supply chain process modeling methodologies

Several modeling methodologies have been proposed in the field of information system development such as the Structured System Analysis Design Methodology (SSADM), the Soft System Methodology (SSM), the Structured Analysis Design technique (SADT). But these methodologies do not proposed as a method for business process modeling [46, 47]. Regarding the ability to meet the requirement for supply chain process modeling, several most used modeling methodologies including ARIS (Scheer 1999), (Kim &Rogers 2005),(Barnard 2006), UMM (Huemer et al. 2009), (Cheng et al. 2010), and (Verdouw et al. 2011)are compared and discussed in this section. Based on the literature, three criteria are identified to compare similar modeling methodologies for supply chain processes. These criteria include the scope of methodology, Business Process Architecture, and Service-oriented modeling. The scope of a modeling methodology is the extent to which it supports supply chain processes. Business Process Architecture refers to the extent to which the process architecture layers (landscape model, abstract model, and detailed process) are supported by SCM reference model. In addition to applying SOA in enterprises, the identification of services should be supported by service-oriented modeling method. Moreover, a modeling language should not only support the representation of message flow between services but specifies the service transaction.

Table 2 illustrates the comparison of modeling methodologies

Table 2 : Comparison the methodologies for supply chain process modeling

Methodology/ Author & year	Scope of Methodology	Business Process Architecture			Service-oriented Modeling	
		Landscape model	Abstract model	Detailed model	Service identification	Service specification
ARIS [48]	Organizational modeling	- Supported by SAP - Utilized EPC, organization view	-Supported by SAP - Utilized EPC, function view	- Supported by SAP - Utilized EPC, process view	- No service identification	- Only content of Business Logic in implementation is supported
[49]	SCM (general)	- Supported by SCOR level 1 - Utilized UML (Use case diagram)	- Supported by SCOR level 2 - Utilized UML-class diagram	- No detailed process model	- No service identification	- No service specification
[50]	Service supply Chain	-Supported by SCOR level 1	- Supported by SCOR level 2	- Supported by SCOR - Utilized IDEF0 and UML	- No service identification	- No service specification
UMM [51]	e-business	- Supported by SCOR, CBPC, PVC - Utilized UML-use case diagram	- Supported by PVC, SCORCBPC, - Utilize specific worksheets	- Supported by SCOR, CBPC, PVC - Utilized UML (activity diagram)	- No service identification	- Only content of Business Logic in implementation is supported
[52]	Construction SCM	- Supported by SCOR level 1	- Supported by SCOR level 2	- Supported by SCOR - Utilized BPMN	- No service identification	- Supporting Business Logic in implementation
[6]	Demand-driven Supply Chain	- Supported by SCOR level 1	- Supported by SCOR level 2 and thread diagram	- Supported by SCOR - Utilized BPMN	- No service identification	- No service specification

According to Table 2, the methodologies include UMM, [6], [52], [50], and [49] support business process architecture using SCOR; and ARIS uses SAP reference model. Nevertheless, as it has already been discussed, SCOR and SAP have their own limitations in business process architecture. As such, GSCF is utilized in the proposed methodology to provide the necessary support for architecture business process. Although UMM is widely used in business area, it does not make obligatory the utilization of specified process modeling techniques for detailed processes, for, in fact, the question of which technology is more appropriate to use is rested with the model designers. [51]. With regard to service-oriented modeling, the activities of process model, particularly those activities that are internal to partners, must be specified and detailed in service orchestration. As the internal business process is not crucial in UMM, it is not commonly predicted and hence, not detailed in service-oriented view. Though UMM is adequate in modeling collaboration among business processes, it has not only its own limitations in service orchestration but it needs the development of a different methodology for modeling internal business processes in service-oriented view. As illustrated in Table 9.1, [52], UMM and ARIS support the content of business logic in the implementation of the SOA-based project. However, there is no specific service modeling method in these methodologies. Therefore is a Service-oriented methodology aiming at modeling SCP. To do so, it is required to initially analyze the business domains and process areas of the given enterprise. Next, it is necessary to model the business processes, which are to be supported by SOA. Eventually, the process models have to be converted into service orchestration description.

6. Conclusion

The 21st century business environment has to face the challenge of ever-increasing uncertainties in supply chain management. These uncertainties have enforced enterprises to utilize e-supply chain. In this challenging context, business administrators prioritize more novel business processes and IT requirements, which, in turn, lead into more complicated supply chain processes. Supply chain processes have, throughout time, shifted to IT-based business processes based on SOA to augment the agility, integration, and flexibility of IT-based applications in enterprise networks. Thus enterprises have embarked on the implementation of integrated information systems to support their business processes. To this effect, SOA, as a highly capable paradigm in IT, has been increasingly used in SCM and enterprise information systems which, using the Web service technologies, produce innovative patterns for the interpretability and integration of the processes and services.

To address the problem of modeling supply chain process, several reference models have been proposed and designed in the domain of SCM. These reference models support different stages of information system development. Some of the reference models, which have been highly acknowledged in industry and business, are MIT Process Handbook, SCOR, GSCF, VRM, CPFR, ISA-95, and SAP. However, the aforementioned reference models do not support the coordination and interaction of process models in detail. Nor do they support service-oriented approach in supply chain process modeling.

All in all, an appropriate methodology is needed for business-process modeling, specifically in service-oriented approach. Moreover, the methodology must possess applicability for a variety of users such as business managers, process analysts, and IT specialists. The survey of previous research on modeling methodology for SCM reveals that there is need for more attention to the details of a process model, which has to support the service-oriented view. Appropriate tools, proper methodologies, and formal modeling languages are the basic requirements for handling the problems of process modeling in order to procure a comprehensive and transparent supply chain process model. It must be reminded that no modeling construct can thoroughly cover different aspects of a process model. Hence, to represent a process model transparently and accurately necessitates utilized by worksheets, a proper reference model, and a set of appropriate modeling languages to address information system modeling issues. Moreover, in field of supply chain process modeling, future researchers should consider the integration of business logic with business rules as well as performance metrics, which improves the performance of supply chain process.

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