BUSINESS INTEROPERABILITY: DYADIC SUPPLY CHAIN PROCESS DECOMPOSITION USING AXIOMATIC DESIGN

Pedro Espadinha-Cruz  
UNIDEMI, Dept. de Engenharia Mecânica e Industrial  
Faculdade de Ciências e Tecnologia  
Universidade Nova de Lisboa  
Campus de Caparica, 2829-516 Caparica, Portugal

António Mourão  
afm@fct.unl.pt  
UNIDEMI, Dept. de Engenharia Mecânica e Industrial  
Faculdade de Ciências e Tecnologia  
Universidade Nova de Lisboa  
Campus de Caparica, 2829-516 Caparica, Portugal

António Gonçalves-Coelho  
goncalves.coelho@fct.unl.pt  
UNIDEMI, Dept. de Engenharia Mecânica e Industrial  
Faculdade de Ciências e Tecnologia  
Universidade Nova de Lisboa  
Campus de Caparica, 2829-516 Caparica, Portugal

ABSTRACT

In today’s competitive environment, companies must strive to cooperate in order to survive. Supply chain cooperation has become a strong asset relying on large integration and coordination of its well-structured processes. However, supply chain operations are conditioned by interoperability, for which until now is missing a tool that helps managers to identify and solve its problems. This article presents the supply chain process redesign supported by the Axiomatic Design Theory.

Keywords: business interoperability, axiomatic design, supply chain management, process interoperability.

1 INTRODUCTION

The fierce competition between companies requires networked cooperation such as supply chains (SC), in order to face the current market situation. In this context, business interoperability is an enabler that makes it possible to execute SC operations such as planning sourcing, delivering, producing and returning, in a seamless fashion, permitting a suitable process alignment and information flow and guaranteeing high performance and competitiveness [Huhns et al., 2002]. However, the lack of interoperability is an emerging issue in information technology (IT) based cooperation.

In this work we present a method to decompose the processes between two supply chain actors. The paper is structured as follows: section two makes a brief review on the key topics (business interoperability and supply chain operations); section three describes the methodology for analysing and re-designing the supply chain dyadic cooperation; section four presents an example of the process decomposition between two SC actors supported by Axiomatic Design Theory (AD); and, section five presents the conclusions.

2 BUSINESS INTEROPERABILITY

2.1 BUSINESS INTEROPERABILITY DECOMPOSITION

Legner & Wende [2006] defined business interoperability as “an organizational and operational ability of an enterprise to cooperate with its business partners and to efficiently establish, conduct and develop IT-supported business with the objective to create value”. Since the original concept introduced by IEEE [1990], interoperability has grown into a wider subject, integrating several organizational, operational and technological areas, currently becoming a complex subject [Rezaei et al., 2013]. IDEAS [IDEAS, 2003], INTEROP Framework [Chen et al., 2003; Chen, 2006], ATHENA Interoperability Framework (AIF) [ATHENA, 2007], ATHENA Business Interoperability Framework (BIF) [ATHENA, 2007] and European Interoperability Framework (EIF) [IDABC, 2010; Vernadat, 2010] are examples of frameworks and researches that present different perspectives, which reflect the issues that one must tackle to achieve higher levels of interoperability, that is, to get close to the concept of “optimal interoperability” [Legner & Lebreton, 2007]. Accordingly, and based on the definition of Legner & Wende [2006], we propose the Business Interoperability Components as depicted in Figure 1.

Figure 1. Business Interoperability Components.

These components portray individual perspectives of interoperability that, in each way, contribute to the concept of
Business Interoperability. This approach to the decomposition of business interoperability aims at systematizing the design of dyadic relationships using AD. This approach allows looking at the interoperability components to see how they guarantee an interoperable dyadic relationship.

2.2 PROCESS MODELLING AND THE SUPPLY CHAIN OPERATIONS

Modelling supply chain processes stems in the concept of process integration and coordination [Vernadat, 1996]. The supply chain operations reference model (SCOR), as introduced by [Supply Chain Council, 2010], provides a cross-industry standard in the definition and configuration of supply chain management processes. However, the SCOR model does not show how to proceed to achieve interoperability.

According to Chen [2006], process interoperability (PI) refers to the way internal processes from different companies interact with each other: The identification [ATHENA, 2006], sequencing [Chen, 2006; Chen et al., 2008] and alignment [ATHENA, 2007; Tolk, 2003] of these processes are critical issues when designing the SC operations between two or more firms. Those authors stress the relevance of coordinating the internal processes into an interface or public process.

3 THE METHODOLOGY TO ANALYSE AND RE-DESIGN DYADIC COOPERATION

Figure 2 presents the method that is proposed to deal with the analysis and re-design of supply chain dyads.

![Diagram](image_url)

Figure 2. Methodology to analyse and re-design dyadic cooperation.

In this method, the first step is to analyse and model the dyad interoperability conditions in terms of the business interoperability and in terms of supply chain performance.

3.1 STAGES OF ANALYSIS AND DECOMPOSITION

As mentioned in the previous section, the first step of the method is to determine the dyad interoperability conditions. This is achieved by interleaving the interoperability and the performance analyses, and modelling the interoperability components in a process that we call analysis and decomposition stages (A+D stages) (see Figure 2). The sequence of these stages has to do with the relationship between the business interoperability components. On the top of the method are the managerial and governance aspects, such as the business strategy and the management of the relationships that impact subsequent components. For instance, in business strategy analysis (BSA), the cooperation objectives are addressed and the dyad is analysed to verify if these ones are clear-cut to both companies and if the individual aspects are aligned into a cooperation business strategy. Managerial and governance aspects have impact in operations. Process interoperability decomposition (PID) and process interoperability analysis (PIA) are ruled by the prior aspects of interoperability, thus constituting the focus of this method. All the following stages are associated to the operations taken place in the dyad. For instance, data interoperability decomposition (DID) and data interoperability analysis (DIA) concern to exchange of data between the firms that perform the processes. Issues like semantic alignment, communication paths and data quality are addressed in this stage in order to ensure that the data is properly interpreted, that there are sufficient contact points to exchange data and that data is usable.

In terms of interoperability, the process resources are the information technology assets (software and systems interoperability, as well as objects and hardware interoperability) and the human resources. These resources enable processes and data exchange. As in the case of data interoperability, these resources are connected to the process interoperability.

3.2 PROCESS INTEROPERABILITY DECOMPOSITION (PID) AND ANALYSIS (PIA)

As stated before, process interoperability is the core of the method. Governance and management impact interoperability and two main elements rule the interaction between enablers and resources: the modelling and the analysis of the processes. The first element is the so-called process interoperability decomposition (PID), where individual and interface process identification, sequencing, and monitoring are addressed by using Design Structure Matrix (DSM) [Eppinger & Browning, 2012]. Business Process Modelling Notation (BPMN) [Féder, 2008] and supply chain practices implementation, in order to find which are the aspects that drive cooperation towards better effectiveness and efficiency. Figure 3 describes the method for decomposing a process in a dyad. For each actor in the SC dyad, we propose the characterization of each process (P1), the sequencing (P2) and the identification of the monitoring resources (P3). Next, the processes are aligned with the organisational structure of the company (P4). At last, after representing the company's
internal processes, the interface process is created by aligning individual processes into a collaborative process (PI).
The corresponding design matrix is depicted in Table 2. The dependency between FRs and DPs, which comes from the chosen DPs, conditions the design of the processes. For instance, the establishment of a deadline to cancel orders (DP1.1.1) has direct influence in the definition of the method to validate orders on the purchasing process (FR2.1.1.3).

PID method is applied to FR2. Process identification (PI1) is portrayed by FR2.1, FR2.1.1, FR2.1.2, FR2.2, FR2.2.1 and FR2.2.2. Process sequencing (PI2) is applied to FR2.1.3 and FR2.2.3. Finally, the companies' internal processes alignment (PI3) is applied to FR2.3.

Table 2 Design matrix for the supply chain dyad.

|     | DP1 | DP2 | DP2.1 | DP2.2 | DP2.3 | DP2.1.1 | DP2.1.2 | DP2.1.3 | DP2.2.1 | DP2.2.2 | DP2.2.3 | DP2.1.1.1 | DP2.1.1.2 | DP2.1.1.3 | DP2.1.2.1 | DP2.1.2.2 | DP2.1.2.3 | DP2.2.2.1 | DP2.2.2.2 | DP2.2.2.3 |
|-----|-----|-----|-------|-------|-------|---------|---------|---------|---------|---------|---------|------------|------------|------------|------------|------------|------------|------------|------------|
| FR1 | X   |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2 | X   | X   |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR1.1|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.1| X   | X   |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.2|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.3|     |     | X     |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.1.1| X   |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.1.2|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.1.3|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.2.1|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.2.2|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.2.3|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.1.1.1|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.1.1.2|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |
| FR2.1.1.3|     |     |       |       |       |         |         |         |         |         |         |            |            |            |            |            |            |            |            |

Figure 4: Company B's purchasing business process model (DP2.1.3).
As for FR₂, stating the main operations and the procedures that must be used to achieve the sourcing and delivery goals specifies the process considerations. FR₂.1.3 corresponds to the alignment of the tasks of company B with the business process flow. The existing conditions of company B are presented in Figure 4. The process sequence is a direct consequence of the FR and DP decomposition. For instance, purchasing condition DP₁.1.3 establishes that the payment activity is preceded by a set of parallel activities: invoicing and reception of materials, which are requirements for making payments. Delays in any one of those activities will delay the payment to company A. Also, the condition DP₁.1.2 results in an additional process (see (9) in “Figure 4.”) that, in case of order rejection delay, will result in negotiation of penalties.

In turn, the process of company A is presented in Figure 5, which portrays the sequence of the business procedures that should be performed to receive (FR₂.1.1) and validate orders (FR₂.2.2).

The next step in the proposed method is to align these processes with the company’s organisational structure. In this example we are dealing only with one company section. Hence, the next step is to design the interface processes. Here, data, material and currency flows are mapped to interconnect the business processes. The result for the existing conditions is presented in Figure 6.
The method presented in section 3 allows guiding the axiomatic design application by interleaving the analysis and the decomposition stages, while keeping the integrity of the business interoperability issues that are related to the industry sector under analysis.

The proposed method for process decomposition allows linking the governance and managerial issues to the operational reality of business. This is useful in dyad analysis and design because it allows keeping track of previously defined aspects when advancing the design. The presented example demonstrates that the cooperation objectives are very relevant in the process design, such as in the case of order cancellation deadline that influences the order validation processes in both companies.

The Business Process Model Notation (BPMN) and the Design Structure Matrix (DSM) have particular relevance in modelling processes. BPMN allows easy forms of representing process, material, information, and currency flows and provides suitable symbols to represent information technology assets, users, communication, etc. As for the DSM approach, it allows to go deeper in the interaction between processes. As illustrated by Figure 7, the interactions that occur in the interface between the two companies become evident and it is possible to check where a process begins and ends. On more complex processes (eg, representing all the supply chain operations, such as production, planning, sourcing, delivery and returning) it is possible to allocate processes to organisational sectors (as proposed in section 3.2), and to verify the process alignment and distribution through clustering algorithms.

Future work will concentrate on applying the next stages of the proposed methodology. For example, after defining the process interfaces, data exchange will be modelled and analysed in order to identify information barriers, such as semantics faults, or database heterogeneity. At last, using simulation tools it will be possible to study various scenarios without interfering with the actual system, thus providing the solution that results in less cost and time.

6 REFERENCES


5 CONCLUSION

The present research contributes to developing an integrated tool to assess and re-design IT-supported cooperation, using a systematic approach to identify interoperability problems, as well as to select optimisation tools to eliminate or to mitigate them.


