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Frank Geert Goethals
IESEG School of Management, Lille, f.goethals@ieseg.fr

Monique Snoeck
Faculty of Business and Economics, K.U. Leuven, monique.snoeck@kuleuven.be

Wilfried Lemahieu
Faculty of Business and Economics, K.U. Leuven, wilfried.lemahieu@kuleuven.be

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Frank G. GOETHALS*, Monique SNOECK** & Wilfried LEMAHIEU**

* IESEG School of Management (LEM-CNRS), Lille
** Faculty of Business and Economics, K.U. Leuven

ABSTRACT

Inter-organizational systems integration can happen in many ways. Depending on the setting, one integration solution is more appropriate than another. If companies are to decide on the most appropriate solution for them, they need to know what all possible solutions are they can choose from and on what aspects these differ. The research question that is answered in this paper is on what relevant classificatory basis we can distinguish IOSI solutions; and given this classificatory basis, what is the complete set of IOSI solutions to choose from? *We used a grounded theory approach, studying several inter-organizational integration cases, standards and technologies. The theoretical contribution of this paper is that it identifies a six-dimensional inter-organizational systems integration solution space. The six dimensions concern data design, process design, process execution control, task execution, data transmission and data storage, each of which is considered from a (de)centralization perspective. These (de)centralization dimensions are, at least in theory, orthogonal to each other. The research is relevant for practitioners because taking a position on the dimensions implies choosing a solution with distinct properties. Properties of solutions are discussed so as to make it easier for companies to choose an appropriate solution. The main novelty of the paper is that it defines a comprehensive integration solution space by introducing the important concept of centralization at the level of inter-organizational information systems.*

Keywords: Inter-organizational systems integration, Centralization, Inter-organizational processes, Inter-organizational data sharing.

RÉSUMÉ

L'intégration des systèmes inter-organisationnels peut se produire de plusieurs façons. Selon la situation, une solution d'intégration est plus appropriée qu'une autre. Si les entreprises veulent choisir la solution la plus appropriée pour elles, elles ont besoin de connaître toutes les solutions possibles parmi lesquelles elles peuvent choisir et comprendre sur quels aspects elles diffèrent. La question de recherche à laquelle il est répondu dans cet article est sur quelle classification appropriée peut-on distinguer les solutions IOSI ; et sur base de cette classification, quel est l'ensemble complet des solutions parmi lesquelles choisir ? *Nous avons utilisé une approche basée sur la théorie ancrée (*grounded theory*), étudiant plusieurs études de cas d'intégration inter-organisationnelles, des standards et des technologies. La contribution théorique de cet article est qu'il identifie six dimensions de l'espace des solutions d'intégration. Les six dimensions concernent la conception des données, la conception des processus, le contrôle de l'exécution des processus, l'exécution des tâches, la transmission de données et le stockage de données, dont chacune est considérée dans une perspective de (dé)centralisation. Ces dimensions de (dé)centralisation sont, du moins en théorie, orthogonales. La recherche est relevante pour les praticiens car prendre une position sur les dimensions implique le choix d'une solution avec des propriétés distinctes. Les propriétés des solutions sont discutées afin de faciliter le choix d'une solution appropriée par les entreprises. La principale nouveauté de l'article est qu'il définit un espace global de solutions d'intégration, en introduisant le concept important de la centralisation au niveau des systèmes d'information inter-organisationnels.*

Mots-clés : Systèmes interorganisationnels, Integration, Centralization, Processus interorganisationnels, Partage de données.

1. INTRODUCTION

The focus of enterprise systems is shifting from an internal to an external orientation (Daniel and White, 2005). Many IT departments are involved in inter-organizational systems integration (IOSI) efforts. This research gives insight into IOSI by identifying dimensions on which IOSI solutions differ. As will become clear, such 'solutions' are *solutions to two basic problems* with which collaborating companies are confronted: a *data sharing* problem and a *process integration* problem. Collaborating companies (1) should (only) have access to valid information on which they would agree they need to have access to, and (2) should appropriately align the tasks that need to be executed in an end-to-end process and control the execution of those tasks. Companies can deal with those problems in different ways. It is, however, unclear what all different options are that companies can choose from. If companies are to behave mindfully (as defined by Swanson and Ramiller, 2004), they should at least know from what options they can choose. Our research goal was to give a structured, logical and easy to understand overview of IOSI solutions. Differences between solutions would be considered highly relevant if they imply solutions have different properties in terms of variables such as business continuity, ownership, flexibility etcetera (Goethals et al., 2008, 2011). To keep the research results relevant in the long run and to allow us to think beyond the solutions that currently have been implemented, abstraction was to be made from specific technologies. In what follows we first present prior research on IOSI. Next, our grounded theory research approach is explained. Subsequently, we present the Inter-Organizational Systems Integration Framework (IOSIF) we derived. Next, the framework is discussed in relation to prior literature. We finish the paper with conclusions and suggestions for further research.

2. BACKGROUND

Many researchers have already tackled important issues raised by the need for inter-organizational systems. Madlberger and Roztocki (2008) provide an extensive literature review of cross-organizational (and cross-border) integration research. Much research concerns trust and risk issues: Kotlarsky and Oshri (2005) focus on knowledge sharing in global teams; Levy, Loebbecke and Powell (2003) discuss knowledge sharing between small businesses; Clemons and Hitt (2004) study inter-firm contracting; Patnayakuni et al. (2006) and Malhotra et al. (2005) investigate information sharing across the supply chain; Son et al. (2005) study the role of power in EDI usage in customer-supplier relationships and Boonstra and de Vries (2008) show that assessing the parties' power and interests related to the IOS is a success factor. Others investigated the management of inter-organizational processes and data integration (Gosain et al., 2005) and of inter-organizational virtual teams (Malhotra et al., 2001). Yet other research focused on the value of inter-organizational integration systems (Chatfield and Yetton, 2000; Straub, Rai & klein, 2004; Wang, Tai & Wei, 2006). Systems adoption issues were studied imposingly (Johnston & Gregor, 2000; Chwelos, Benbasat & Dexter, 2001; Kauffman & Mohtadi, 2004; Christiaanse & Venkatraman, 2002; Teo, Wei & Benbasat, 2003; Zhu et al., 2006; Robey, Im & Wareham, 2008; Quaddus & Hofmeyer, 2007; White et al., 2007).

Researchers proposed taxonomies of different types of inter-organizational systems. Alt and Fleisch (2001) for example distinguish three types of Business Networking Systems: data-sharing systems, supply-chain management systems and electronic commerce systems. Hong (2002) contrasted strategic and operational inter-organizational systems. Choudhury (1997) discerns electronic monopolies, electronic dyads and multilateral IOIS. Goethals (2005) contrasted Extended Enterprise integration with Market B2Bi. Elgarah et al. (2005) focus mainly on the distinction between network relations and dyadic relations in inter-organizational data exchanges. Damsgaard and Truex (2000) distinguish binary trading relationships, market-like transactions and the hub-and-spoke model based on the actors' relationships. Boonstra and de Vries (2005) reveal the existence of three types of inter-organizational systems: unlikely, unbalanced and balanced.

Diverse Business-to-Business integration (B2Bi) standards, technological frameworks and software platforms have been developed during the last decade. Typical standards are the traditional EDI (Electronic Data Interchange) and the XML (Extensible Markup Language) standards which can be grouped into horizontal and vertical industry standards. Horizontal standards include cXML (commerce XML) and UBL (Universal Business Language) and Web Services standards such as SOAP (Simple Object Access Protocol) and BPEL (Business Process Execution Language). Vertical standards, which are industry-specific, include ACORD (for the insurance industry), HR-XML (for Human Resources industry), Legal-XML (to exchange legal data), NITF (News Industry Text Format) and OFX (Open Financial Exchange). Well-known frameworks are ebXML (which is a horizontal framework) and RosettaNet (which is a vertical framework). Software platforms have been provided by many vendors such as SAP (NetWeaver platform), IBM (WebSphere platform), Microsoft (.Net), and Eurostep (Share-A-Space).

The concept of centralization was considered repeatedly in intra-organizational studies but was hardly investigated in IOSI research so far. Centralization has for example often been investigated in the context of IT governance (e.g., Xue et al., 2008; Brown & Magill, 1994). Links were shown between the level of decentralization of the IT structure and organizational competitive strategy (Tavakolian, 1989). Similarly links were documented between the level of decentralization of the IT structure and organizational structure (Fiedler, 1996). Centralization is one of the key variables in organizational design and (de)centralizing some practice has far-reaching consequences (Mintzberg, 1992). Advantages and disadvantages of (de)centralization have been discussed extensively in organizational literature (Harris & Raviv, 2002; Stein, 2000; Khandwalla, 1974) and IS literature (Streeter, 1973; King, 1983; Bray, 1982; Cash et al., 1992; Evaristo et al., 2005; Taylor & Tucker, 1989; Damsgaard and Truex, 2000). Considering the inter-organizational level, centralization received attention in *organization literature* (Alexander, 1995) but was hardly treated in IOSI literature. The question arises what is the role of centralization in IOSI architectures. Anderssen et al. (2008) state that architectural knowledge is important for the development of architectures capable of serving the goals of heterogeneous actors in IOS.

As is clear from the literature review above, issues such as risk, adoption and value of inter-organizational systems as well as different technologies have been studied extensively. Still, we are not aware of research that gives insight into the architecture of IOSI solutions and the role of centralisation in those architectures. Nevertheless, the IOSI solution that is selected influences the risk, adoption and value of IOSI and studies on those topics would thus benefit from taking the IOSI solution architectures into account (e.g. as a matter of taking a representative sample of the IOSI solution population). To clarify what we mean with an IOSI solution, we present below two IOSI cases we studied, focusing on the centralization aspect. The two cases reflect the two big classes of integration practices that organizations can pursue (discussed by Clergeau and Rowe, 2005): they can either pursue the realization of an inter-organizational business process, which implies a need to share data, or they can pursue pure data sharing (without a real inter-organizational business process on top of it). The first case is a pure data integration case whereas the second case is an example of a process integration case including data integration practices. After presenting the two cases, the research questions are derived.

2.1. Social Security Crosspoint Bank (Kruispuntbank)

The Belgian "Kruispuntbank van de Sociale Zekerheid" (literally: Social Security Crosspoint Bank) provides necessary data to all Belgian organisations involved in social security. It is not conceived as a central database, but as a "traffic controller" at the crosspoint (hence the name) of the data streams between the organizations involved in social security. The Kruispuntbank only contains references to personal data, without storing the actual data. The Kruispuntbank contains information about which social security institutions maintain files of a specific citizen, in which role(s) that citizen is known by the institutions, and the period in which the citizen is/was associated with that institutions. This decentralized storage approach has as main advantage that there is no discussion about data ownership: each data owner maintains the data, enforces access rights etc. at its own premises, where the data are stored. The main consequence is that there is no party that has a global picture of a citizen, which is fine from a privacy perspective. However, this requires frequent data exchanges to synchronize pieces of redundant data. The respective institutions never exchange data directly, but always communicate through the Kruispuntbank, which acts as a central hub.

The data exchange formats are decided upon centrally by the Kruispuntbank. Data exchanges happen through structured electronic forms. Currently, several formats are used (a.o. the EDIFACT based IHFN), which are all gradually migrated to XML. Because of the centrally defined message formats and centralized data transmissions, the respective institutions remain completely independent from one another: they only have to comply with the Kruispuntbank standards but not with the "local" storage approach of each individual party. This makes it fairly easy for new players to "plug" their system into the Kruispuntbank infrastructure and for the government to control the data sharing. On the other hand, the Kruispuntbank as a central authority also has a limiting effect on the exchanges that are supported. There is basically no possibility for two parties to exchange information beyond what is centrally supported by the Kruispuntbank.

2.2. Motorcycle transportation

To show an example of a process integration approach, we turn to a case where motorcycle *carriers* transport motorcycles from the motorcycle *manufacturer* to the motorcycle *dealers*. First, however, we briefly consider the underlying data integration approach that is used to exchange the necessary inputs, outputs and event notifications during the process execution.

The data integration solution in this case is different from the Kruispuntbank case. For the design of data exchanges, the manufacturer decides unilaterally upon what data is to be shared, upon the data formats etcetera. The carrier for example has to foresee track-and-trace information if he wants to be a carrier for this manufacturer and after each delivery he has to send a performance report to the manufacturer. This is of course an easy position for the manufacturer, but harder for the carriers, some of who do transports for other companies as well. All data is stored centrally in the same place: data on the transports that need to happen are stored on a central server of the manufacturer and information from the carrier (such as the track-and-trace information) has to be uploaded to this central storage space. This way, it is clear to all parties what *the* valid copy is of data about transports and parties can read data from this storage space whenever it suits them. The other way around, a sender can upload his data even if a final receiver's system is not operational at that time. Finally the manufacturer acts as a centralized data transmission hub as well. The request for a motorcycle is not communicated directly by the dealer to the carrier. Communication between dealer and carrier is mediated by the manufacturer who can change file formats and can aggregate data (more specifically by adding the time at which the motorcycle can be picked up) so that the carrier gets all relevant data on some transport in one message.

Turning to the process integration approach, the motorcycle manufacturer has defined the steps in the process, the task executors, the execution location, etcetera. The strongest party in the collaboration makes unilateral decisions. For the manufacturer, this has the advantage that he can manage the global process picture and can optimize the overall process at his convenience.

There is not a single party that is controlling the entire process execution. Every day the manufacturer decides on the transports that are needed the next day and the carrier makes a transportation planning for the next day. That planning task is not triggered by the manufacturer. Rather, the carrier decides himself when to make the planning and chooses himself when he looks whether new data is available on required transports to make his planning. As a result, the manufacturer does not actively trigger the diverse tasks in the entire process execution. The disadvantage is that no single party actually knows the state of the entire process at every point in time, but in this case this was not really considered a problem.

Some task executions in the process have been centralized. A remarkable example of this is that the manufacturer himself creates the invoices he has to pay to the different carriers. Consequently, the different carriers don't do this task; only the manufacturer does it. So far, this way of working went smooth: not a single invoice has been rejected by the carriers. The main advantage of this approach is one of quality management: the invoices can be directly generated internally from other information that is already available in the systems of the manufacturer. As a result, the manufacturer does not have to investigate the correctness of an invoice that is received from a carrier. This advantage results from the fact that the manufacturer operates as a central party, due to its dominance in the collaboration.

2.3. Research questions

The two cases above show that the IOSI solutions that were chosen have specific properties. In the Kruispunt-bank-case, there was for instance no ambiguity about 'data ownership', while data ownership is less clear in the motorcycle transportation case. The IOSI solutions that are appropriate for different companies can differ considerably. We are not aware of research that investigates the alignment of the integration solution with the business. For example, some businesses require 'flexibility' in the sense that it should be easy to replace an actor in a process by another actor who provides a similar standard transaction. Other businesses need flexibility in the sense that it should be easy to redesign the process without a desire to switch collaborating partners. Different IOSI solutions offer different types of flexibility. Organisations should thus ground the choice of an IOSI solution in their organizational specifics. To choose the best integration solution, companies need to know from which solutions they can choose. However, it is currently still unclear what the different integration solutions are that companies can choose from, although it has been stated that architectural knowledge is important (Anderssen et al., 2008). The goal of this paper is to define the B2Bi solution space and to illustrate the relevance of choosing an appropriate solution by showing that different solutions have different properties (relevant to business people).

As more and more IOSI technologies are being put forward and the competitive environment requires companies to integrate their systems efficiently and effectively (and thus to pursue alignment of inter-organizational systems), there is an increasing need to understand options in inter-organizational systems integration. This paper has the goal to deal with the following research questions:

RQ1: On what relevant classificatory basis can we distinguish IOSI solutions?

RQ2: Given the classificatory basis identified in RQ1, what is the complete set of IOSI solutions to choose from?

3. RESEARCH METHODOLOGY

A grounded theory approach (Glaser & Strauss, 1967; Martin & Turner, 1986; Turner, 1983) was applied to deal with these research questions. We tried to start with a blank page. On the one hand, at the start of the research project we were not aware of existing descriptions of the IOSI solution space. On the other hand, considering solution spaces used in other settings (e.g., at intra-organizational level) could have limited the ability to define a comprehensive solution space that fits the inter-organizational field. We did not want old borders to limit our creativity to detect new solutions and we did not want to impose existing concepts on the emergent new concepts. In other settings (e.g., the intra-organizational level) other solutions may be (un)attainable and (in)appropriate. Moreover, the goal was not to identify *patterns* of often used systems as was done in prior research in other settings but to find a more complete specification of the solution space. In order not to be biased by characteristics of solution patterns identified in other settings, we let the data speak to us. In line with the grounded theory approach, we gathered data relative to our research question and we used constant comparison as the data analysis method. The definition process required several iterations of studying systems and adapting the definition (as is generally the case in grounded theory research, Glaser, 1992; Martin & Turner, 1986). Constant comparison was the primary data analysis method we used. Through reading and rereading the texts (including typed out interviews) and clustering them, categories began to emerge. Open coding was used in the sense that data was assigned to categories that were identified from the data. Furthermore, we investigated the relationships between the different categories (so-called axial coding). Selective coding lead to the identification of centralisation as the core variable. We did the coding process iteratively, so that over time rather complex dimensions were derived which were contractions and reconceptualisations of former dimensions (such as the design dimensions and the data storage and task execution dimensions mentioned below). Following Glaser (1998), we did no theory literature review before the study, but we did a literature review towards the end of the study. That literature was then merged with

Small pharmacies: ordering process	1 interview with sales person of pharmacy software (1 hour) + 2 interviews with two pharmacists (about 1 hour each)
Big supermarket-chain: ordering process	1 interview with IT responsible coordination center (1,5 hour) + 2 separate interviews with business responsibles of 2 individual supermarkets (about 1 hour each)
Tradcom: small indirect products selling platform (end-to-end sales process)	1 interview with IT responsibles central platform + business responsibles of 2 suppliers (3 hours)
Big car producer (producing for several brands; production planning process)	1 interview with IT responsible (2,5 hours)
Big motorcycle producer (different from car producer above): delivery process	6 interviews with IT responsibles of motorcycle producer (on average 1,5 hours per interview) + 2 interviews with 2 motorcycle dealers (about 1 hour each) + 3 interviews with sales people of 3 transportation companies (about 1,5 hours each)
SAP: Technology Vendor	3 interviews with a sales person (of about 1,5 hours each) + 2 interviews with an IT consultant (of about 2 hours each)

Table 1: Overview of the major resources.

the theory. The process of gathering data and analysing additional systems was stopped when theoretical saturation was attained; i.e., when no new concepts emerged when studying additional systems and we agreed additional systems fit the current solution space and did not suggest changes to the solution space. Biases were limited in the sense that the lead researcher (with a background in Applied Economics) was in the PhD program and had limited background knowledge about IT. The two other researchers had a vast knowledge of IT. Discussions among the researchers were conducted to point the lead researcher to additional sources (such as cases) that would allow him to get a fuller understanding of integration technologies. The lead researcher induced the definition of the solution space and judged the appropriateness of the definition together with the other researchers.

Primary and secondary resources were used. Table 1 gives a short overview of the major resources.

The primary resources are cases we studied by talking with people from companies that were conducting inter-organizational integration and with people from IT providers that were involved in implementations. In some cases this involved only one interview. In other cases (especially those studied more towards the end of the project) real in depth studies were conducted to get a very detailed picture of what was actually happening, involving many more interviews and studying much more internal documents. The cases involved primarily unstructured interviewing. We also studied internal documents and relevant external information (if available). Given the inter-organisational nature of the projects, we often contacted people from different companies that were involved to get the full picture. Interviews then often took the form of crossed interviews. Following Glaser and Strauss (1967), we used theoretical sampling: the cases were selected based on their theoretical relevance to further the development of emerging categories. We therefore selected cases that were *contrasting* in terms of 'business setting'. For example, we studied the case of the Tradcom-marketplace where customers have a short term relationship with suppliers and the case of a motorcycle manufacturer where companies have a long term relationship. It was hoped that in contrasting settings different integration approaches would be installed, so chances of detecting differences were supposed to be bigger. Nevertheless, we also compared systems used in *similar* business settings because this was supposed to elevate sensitivity to differences (still following Glaser and Strauss, 1967). We typically studied the latter through secondary resources (i.e., case descriptions that were offered by others) because it is harder to find several primary resources within the same business setting that are willing to co-operate. For instance, we studied the sharing of electronic patient records in the Netherlands, Belgium, Croatia and the UK.

As secondary resources, we also assessed what solutions were offered by standards and software packages. We investigated Web services standards (including SOAP, WSDL, UDDI, WSS, XML Signature, XML Encryption, SAML, WS-ReliableMessaging, BPEL, WS-CDL, WS-Addressing, BPMN, WS-Policy, WS-RM Policy, WS-CAF, WS-Context, WS-Coordination, WS-AtomicTransaction and WS-BusinessActivity), and other horizontal standards such as cXML and UBL. Frameworks such as ebXML (including ebMS, BPSS and ebXML CCTS) and Rosettanet were also included. Furthermore, vertical industry standards we studied include XBRL, HR-XML, HL7, IFX and ACORD. The systems we studied, offered by vendors, included SAP's Netweaver platform, Eurostep's Share-A-Space solution and Federation's federated data repositories solution. Studying standards and software packages typically happened by assessing the official standard specifications and software descriptions found on the vendor's website, books, and white papers with implementation case descriptions. The framework that resulted from the analysis is presented in Section 4.

4. FINDINGS: THE INTER-ORGANIZATIONAL SYSTEMS INTEGRATION FRAMEWORK (IOSIF)

In what follows we answer the research question by presenting the framework that arose from our study.

We first give an overview of the entire framework. Next, the framework's dimensions are presented individually in detail. To make the framework useful, we finish this section with a presentation of properties of different IOSI solutions. The presentation of the framework in this section is enriched with references to existing literature and theory. This enrichment was only done after the core research was completed (following Glaser and Straus, 1967).

4.1. The six (de)centralization dimensions of the IOSIF

Our comparison of the different systems revealed six (de)centralization dimensions on which companies have to take a position (shown in Table 2).

Of the six dimensions, three relate to process-control (left column of Table 2) and three to data-control (right column). The need to distinguish data from processes arose from our case studies and a number of standards, and it fits the distinction made by Clergeau and Rowe (2005). Case studies revealed that some organizations share data in a process-agnostic way. As shown above, the Belgian "Kruispuntbank van de Sociale Zekerheid" (literally: Social Security Crosspoint Bank) provides data to Belgian organizations involved in social security. This data sharing happens without an inter-organizational business process (i.e. "a set of logically related tasks performed to achieve a defined business outcome", Davenport and Short, 1990) on top of it. Similarly, the RosettaNet standard acknowledges that data may be transmitted through third party routing entities, but that such an exchange is still considered a peer-to-peer message exchange as far as the process is concerned. While a data integration solution can exist on its own (so that parties only need to make choices in the right column of Table 2), a process integration solution always requires a data integration solution (so that parties need to make choices in all six cells in Table 2).

Looking at Table 2 from another viewpoint, two dimensions concern design-time (the top row) and four concern execution-time (the two bottom rows). The distinction between design time and execution time arose based on the observation that companies try to deal with similar problems in different ways. For example, when it comes to the data format used in message transmissions, companies may enable conversations by 'designing' a common language. If they do not design a common language, they need to perform additional tasks at execution time to deal with incompatible data formats. They might e.g. involve intermediaries in message transmis-

	Process-control related	Data-control related
Design control	Process design	Data design
Execution control	Process execution control	Data execution: transmission
	Task execution	Data execution: storage

Table 2: The B2Bi (de)centralization dimensions of the IOSIF.

sions which take care of message translations. Observing such practices makes the design and execution stages visible. Similarly, on the process side we noticed that the terms 'choreography' and 'orchestration' (as used in the Web services domain) were obscured because they melt together design and execution issues (see below).

We observed the centralization concept is different for design-related and execution-related dimensions. When considering 'design-related' dimensions, this research concurred with Fredrickson (1986) that centralization specifies the level of 'concentration in decision-making rights'. In the most extreme case of centralization, design decisions are not even taken just centrally by one of the collaborating companies but are moved up a level to standardization organizations. On the other extreme – thanks to innovations in ICT – it has become easier to cooperate in a distributed mode and globally distributed collaborations and virtual teams have become increasingly common; so that design decisions can be decentralised (Carmel & Agarwal, 2002; Herbsleb & Mockus, 2003; Sarker & Sahay, 2004; Kotlarsky & Oshri, 2005).

Looking at the execution dimensions, we concurred with Jain et al. (1998, p2) in that decentralized systems 'allow local processing and storage of data and greater end user control'. Centralization then moves processing and data storage away from local parties to one central institution (which may be owned by the collaborating partners or even by external parties such as governments or software providers).

4.2. Data-control dimensions

Three dimensions concern data-control. Together these dimensions form the inter-organizational *data* integration solution space, represented in Figure 1. Choosing a good data integration solution (and thus knowledge about the solution space) seems important as it has been shown that skills in managing inter-organisational knowledge flows are a source of competitive advantage (Dunning, 1988; Levy et al., 2003). In what follows the three dimensions are derived.

4.2.1. Data Design

The data design dimension refers to the way decisions are made with respect to the data sharing. In line with the Zachman framework for Enterprise Architecture (Zachman, 1987), one can interpret this as deciding upon the what, how, where, who, when and why of the data sharing. Data sharing decisions can be made centrally or decentrally. Sometimes decisions are centralized at the level of an entire industry. The data sharing is then not adapted to the needs of specific parties. For example, regarding electronic patient files, individual family doctors cannot decide individually what information they share via the system; this is regulated centrally at governmental level. Sometimes the centralization is limited to the level of the Extended Enterprise (defined as *a collection of cooperating legal entities*, Goethals et al., 2005). Very often there is one strong party in Extended Enterprises which makes the design decisions, usually to its own advantage. Other parties can only follow. One example of this is the

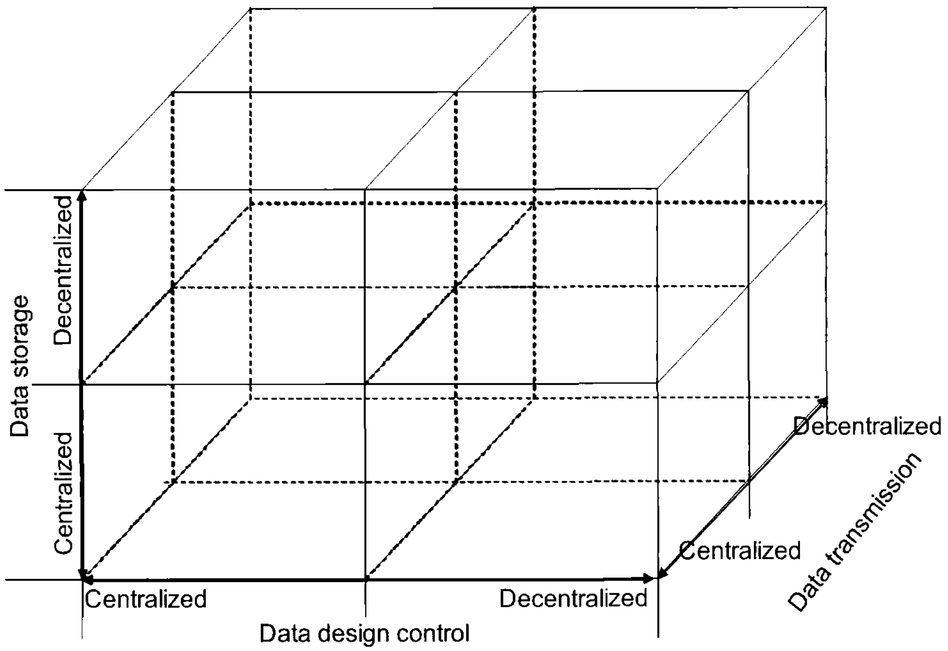

Figure 1: The inter-organizational data integration solution space

case of a (big) Swedish manufacturer that obliged its suppliers to send invoices using a specific electronic format. Suppliers who were not able to do so would no longer be considered for doing business. In decentralized cases parties bilaterally agree on content that is to be shared, on data formats, etc. This dimension is a continuum. We note that Weill and Ross (2005) defined a 'federal' IT governance model, and in 1990 Von Simson already discussed the appropriateness of a hybrid IS organization.

The 'data design' dimension is essentially very complex. A central consortium (such as the RosettaNet consortium) may define a global datamodel, what messages can be exchanged within some industry etcetera. Companies may still decide freely whether they adopt the standard. Mintzberg (1992) and Patterson (1959) analyzed the decision process in several steps. Given their analysis, the design dimension could be split up. We could for example discern between the number of parties that make decisions on the one hand, and the number of parties that give advice as to what they believe should be decided. To keep the framework simple the design-dimension was not untangled in this paper. Weill (2004) wrote a paper on IT Governance (de)centralization respecting this specific division.

4.2.2. Data Execution – transmission

Data transmissions can happen directly from data provider to data receiver or via a central system. In the case of Tradcom.be, several suppliers of indirect products wanted to make it easy for new customers to do e-procurement. The Tradcom platform was set up as an intermediary between customers and suppliers. Tradcom is able to accept customer's messages in many formats. The suppliers that are connected to the Tradcom platform, however, have a long term relationship with the platform (as they commonly own the platform) and are willing to adapt their own systems to communicate with the Tradcom platform using a Tradcom-specific XML format. Tradcom then takes care of the transformation from the customer's format to the Tradcom-specific XML format, guaranteed message delivery to suppliers etcetera. As another example of centralized data transmissions: social workers sharing electronic patient files in the Netherlands and in the UK use intermediaries through which all information is transmitted. Thanks to this intermediary parties don't need to know which other parties have data on some patient. In many other cases, however, information is transmitted point-to-point, directly from a party who has some data to a partner that needs to receive this data.

4.2.3. Data Execution – storage

The data that is to be shared may be stored in a central repository that is shared by all partners, or in different locations. Centralised storage spaces are typically more efficient and manageable than decentralised ones (for example from a back-up viewpoint). On the other hand, parties may be reluctant to give up control (if not data ownership) in favour of a central authority. Data storage conceptualisation is a complex issue. Often local sites make offline data copies, knowing the data may be outdated and knowing the up-to-date data is available in one or more other storage spaces. One marketplace we studied only updated its supplier catalogues overnight. Prices and quantity on stock that were communicated to customers, therefore, were said only to be approximative. The only 'valid' copy of the data was stored on the suppliers' local systems.

The data storage dimension can be seen as a contraction of two dimensions on which decentralization can happen. This is illustrated in Figure 2. The direction of the arrows shows a move from centralized to decentralized solutions (following the centralization definition of Jain et al., 1998).

On the vertical dimension it is shown data storage centralization can take the form of having one party storing all data that is needed by others (vs. having different parties storing data). The way social workers share electronic patient files in different countries is a clear example of this dimension. As stated above, social workers in the Netherlands and in the UK share files through a central intermediary. In the Netherlands the intermediary only stores meta-data (i.e., which social worker has information) and picks up the information at the distributed source(s) and forwards it to the information requestor. In the UK, however, this intermediary actually stores the electronic patient files so they are always available. This solution was considered more controversial from a data ownership and privacy viewpoint. In Belgium, the electronic patient file system 'e-Health' was even sued by a human rights league because it was assumed that patient information was stored centrally. (Actually, the e-Health system only stores meta-data.)

On the horizontal dimension it is shown that data storage decentralization can take the form of having several copies of the same piece of data vs. having specific data stored only once. Very often volatile data, such as stock levels, are only stored once within an Extended Enterprise and are transferred in real time. On the other hand, big and rather stable files, such as product designs, are copied to several sites for fast local access.

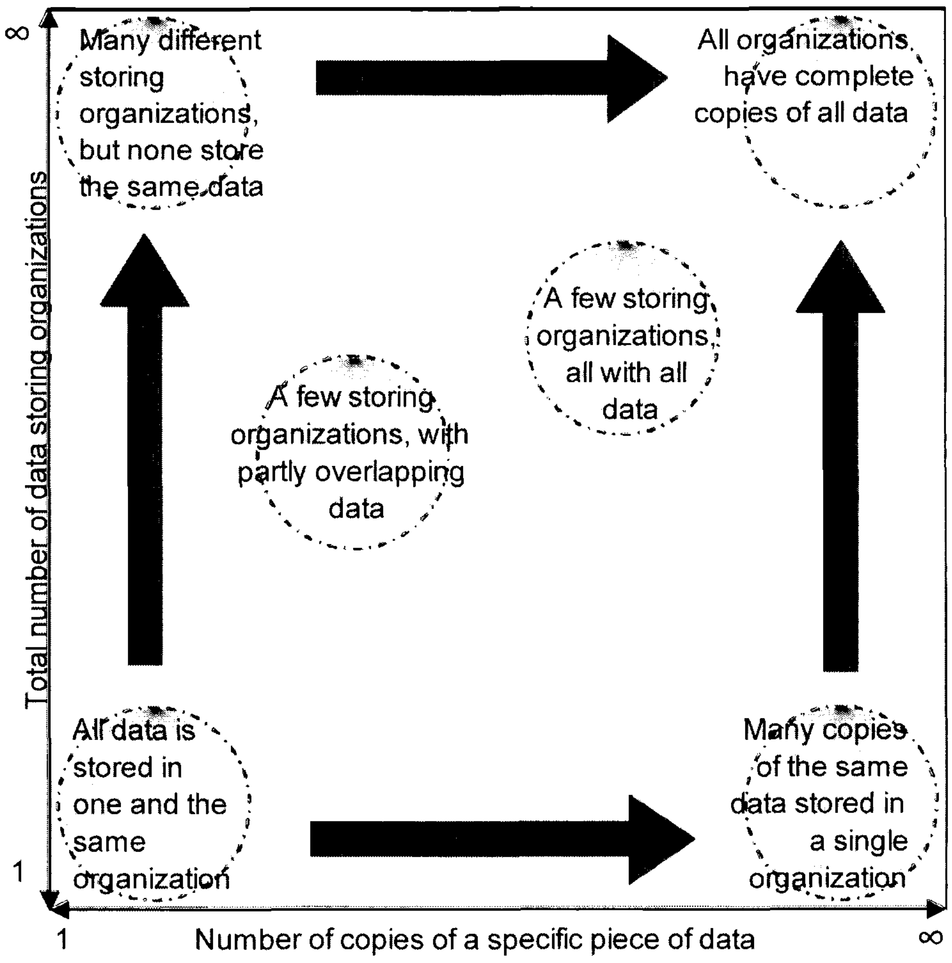

Figure 2: The data storage centralization dimension is a contraction of two dimensions

When contracting the two aspects, with completely centralized data storage all data would be stored together by one and the same party. This is for example how Eurostep's Share-A-Space solution is typically used. When data storage is completely decentralized, theoretically each party would have local copies of all data that is shared in the Extended Enterprise. We note that hybrid solutions exist as well. A number of repositories can be set up in distributed locations. At each site the repository is integrated with local applications. These repositories link and store information from different sources (thus local and remote content are consolidated) but in general do not store a complete picture of all information that is shared in the Extended Enterprise. Users then only have to interact with a single data source. At regular time intervals the originating system sends up-to-date data to its site-local repository. The distributed repositories take care of synchronization. Business rules control data movement and security in accordance with how the originating site intends to share information and with what information target sites are willing to accept (CIMdata, 2003). Honeywell International Defense And Avionics Systems used this approach to share engineering data with its strategic customers in a secure, fast way. They did so by implementing the software solution offered by the company Federation (2006).

4.3. Process-control dimensions

A business process is defined as "a set of logically related tasks performed

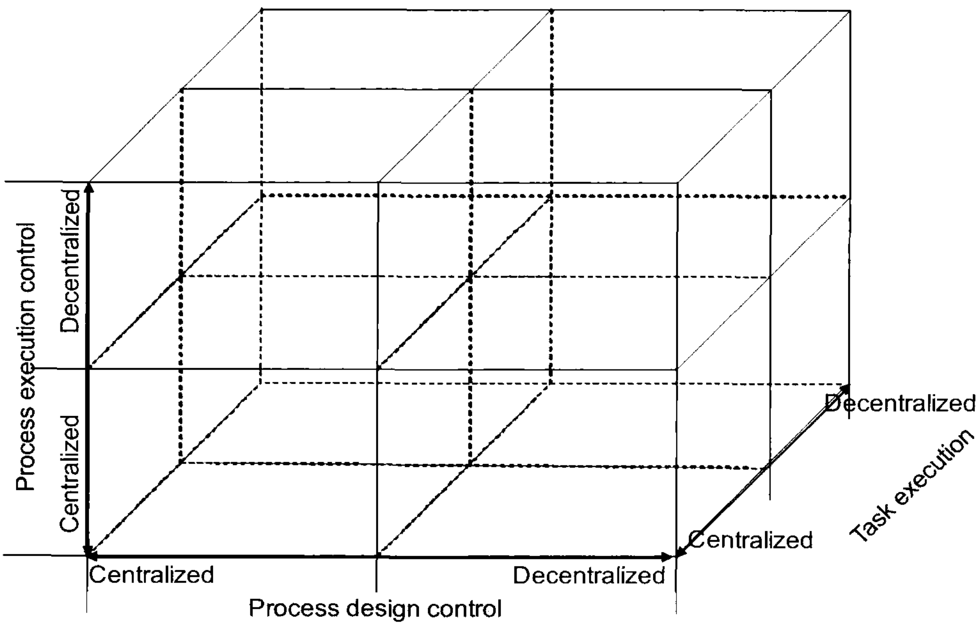

Figure 3: The inter-organizational process-specific integration solution space.

to achieve a defined business outcome" (Davenport and Short, 1990). Three dimensions in our framework specifically concern process-control. These dimensions form the inter-organizational *process-specific* integration solution space, shown in Figure 3. The term "process-specific" is used, rather than "process", because the realization of an inter-organizational business process implies a need to share data (and thus taking a position in the data-integration solution space). The other way around, however, the term "data integration solution space" introduced above is appropriate as companies can decide to set up a data sharing solution with or without building an inter-organizational process on top of that. In what follows the three process-specific dimensions are derived.

4.3.1. Process Design

At design time, decisions with respect to how processes will be realized can be made centrally or decentrally. Generally, if decisions are made centrally, an overall picture of what the entire process looks like will be available and will be managed. In this case some party can take ownership of the entire process, can specify service levels for the end-to-end process etcetera. In case there would be an end-to-end process involving four parties (A, B, C and D), the process could be described in a single BPMN diagram as in Figure 4.

We studied a motorcycle manufacturer who defined the steps in the inter-organizational process, the task executors, the execution location, etcetera. In this case, "centralization" boils down to unilateral decisions by the strongest party in the collaboration. For the manufacturer, this has the advantage that he can manage the global picture and can optimize the overall process at his convenience.

If decisions are made decentrally, there is no overall process picture that is managed, and generally no overall picture of what the entire process looks like will be available. The companies A, B, C and D (as shown in Figure 4) would not possess (nor manage) the picture in Figure 4, but the partial pictures in Figure 5, Figure 6,

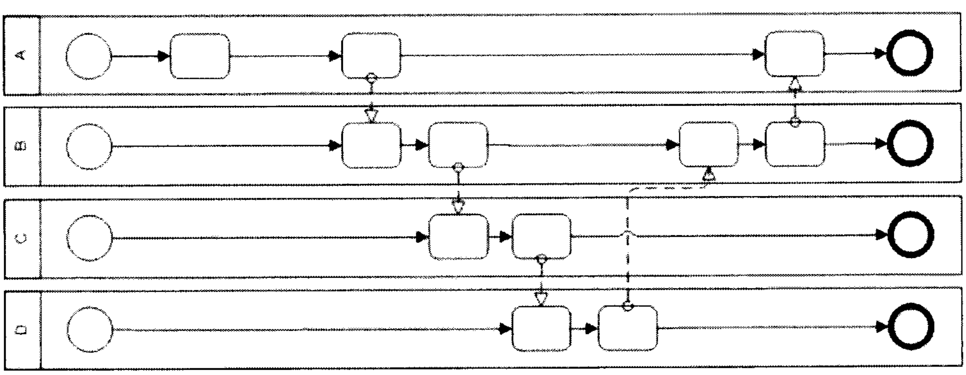

Figure 4: Picture managed in case of a centralized process design

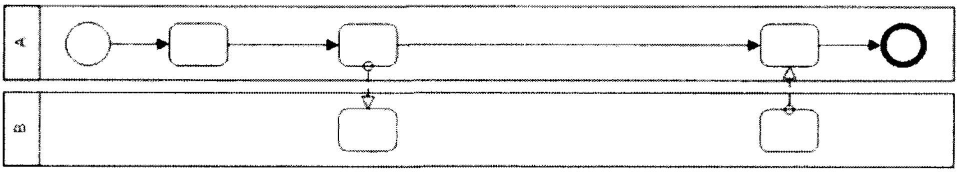

Figure 5: View of company A

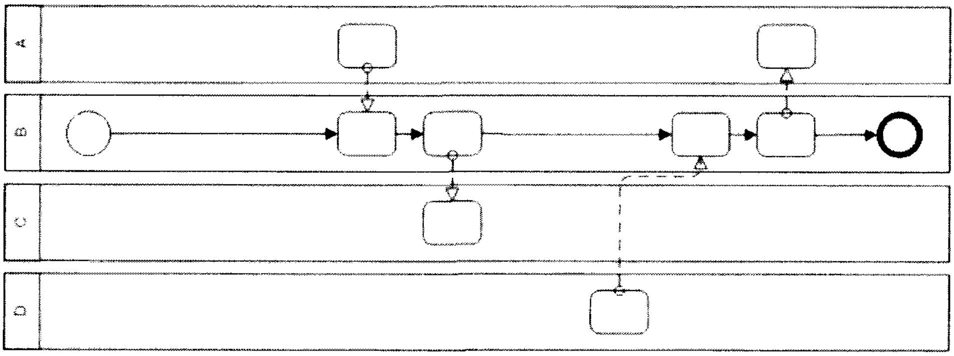

Figure 6: View of company B

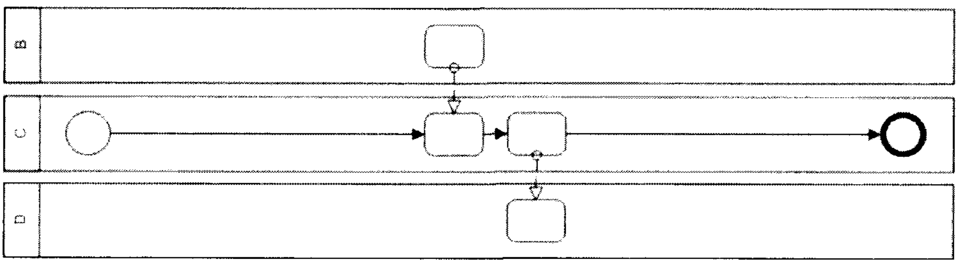

Figure 7: View of company C

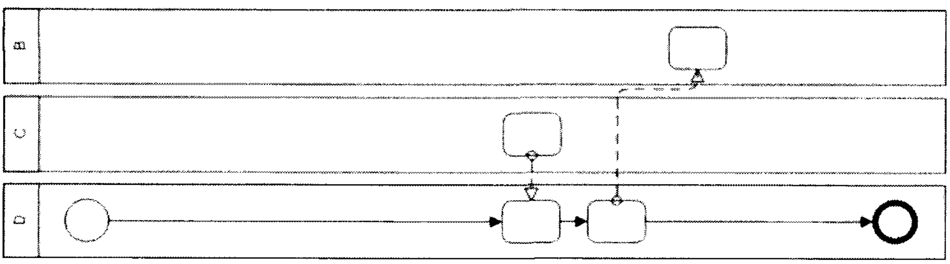

Figure 8: View of company D

Figure 7, and Figure 8 respectively. This way of working enables companies to make twists to the process that are locally considered valuable and would maybe not be understood sufficiently by a central process owner.

A completely centralized design is hard to find in real life. The definition of what is 'completely centralized' depends on what is the definition of the Extended Enterprise: which tasks are considered part of the process under consideration?

4.3.2. Process Execution control

The process execution can be controlled centrally. That is, the different tasks that need to be executed by the respective companies in the course of an end-to-end process can be controlled by a single central Controller (e.g. through a BPEL engine). The central controlling system ('Controller') interprets *the* process definition and is responsible for starting, suspending, resuming and stopping the (Extended Enterprise) process execution (WMC, 1999). Some car manufacturers take care of the coordination of all tasks in end-to-end processes and thus coordinate different carriers, trigger local governments to register and deliver license plates, trigger car insurance companies to draw up insurance proposals, etc. In contrast, in other cases car buyers coordinate parts of the process; for example by triggering the production and delivery of license plates themselves. The latter is similar to the process execution control in the 'Connected Indiscrete' or 'Peer-to-Peer' workflow interoperability discussed in (WMC, 1995). The difference between centralized and decentralized process execution control is illustrated in Figure 9.

Centralised process execution control is for example valuable when monitoring end-to-end service levels is desirable. However, a centralized control may slow down the process. While both, centralized and decentralized process execution control (in relation to a specific end-to-end process) are possible, real life cases often follow a hybrid model. Several parties get control over distinct parts of the process, leading to hierarchical workflow interoperability. This is illustrated in Figure 10. The Controller controls A, B and D's executions. While company B is executing some tasks under the control of the Controller, it controls it-

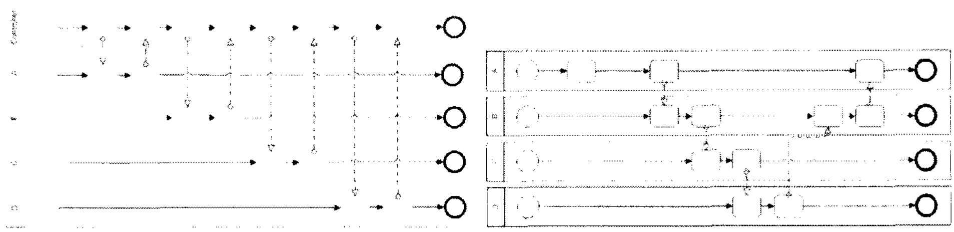

Figure 9: Centralized process execution control (left panel) vs. decentralized process execution control (right panel)

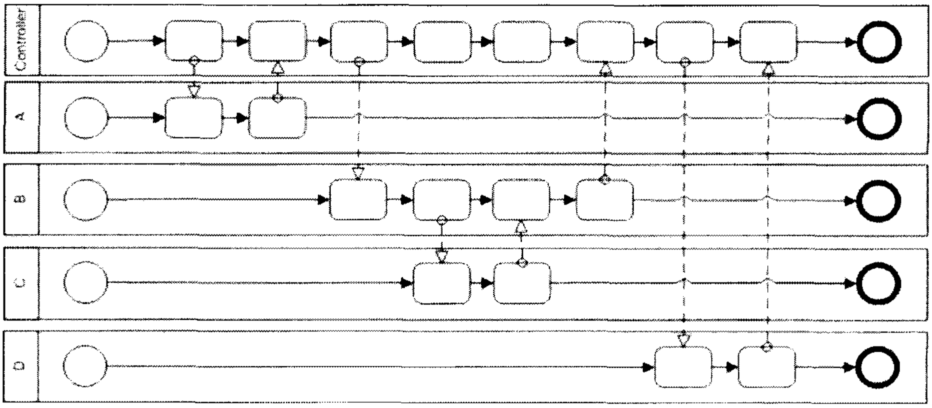

Figure 10: Hybrid model of process execution control

self the execution of some subtasks executed by company C.

4.3.3. Task Execution

Tasks can be executed by a central party that acts as a communal service provider, or decentrally, in which case different companies locally execute tasks. For instance, carriers typically 'create invoices' for the transportation jobs they do for manufacturers. However, in one case we noticed the manufacturer himself drew up invoices he had to pay to his carriers. The 'create invoice' task was no longer done decentrally by several parties.

Like with the 'data storage' dimension, the task execution (de)centralization dimension could be seen as a contraction of two dimensions, illustrated in Figure 11.

The horizontal dimension shows task execution decentralization can take the form of having several parties executing some specific task (vs. having a specific task executed by only one party). TicketCorner – a Swiss ticket seller – currently possesses a ticketing platform. TicketCorner deals with event organizers in two ways. On the one hand, TicketCorner can set up its platform and its distribution channel (including call centers and a point-of-sales network) to sell the tickets. On the other hand, TicketCorner offers its platform to organizers so the organizers can take care of the sales themselves using Ticketcorner's computerized task execution system. In Figure 11 we could say that several organizations in the Extended Enterprise can execute the task using the same system (bottom-right corner). In another Business Model, TicketCorner could offer organizers integrated services only, comprising both platform setup and distribution channel. This would mean a move to the left in Figure 11.

The vertical dimension shows that task execution centralization can take the form of having only one system that executes (or supports manual) tasks (vs. having several systems executing those tasks). The example of the invoice creation mentioned above illustrates this. In the decentralized way of working, all carriers execute

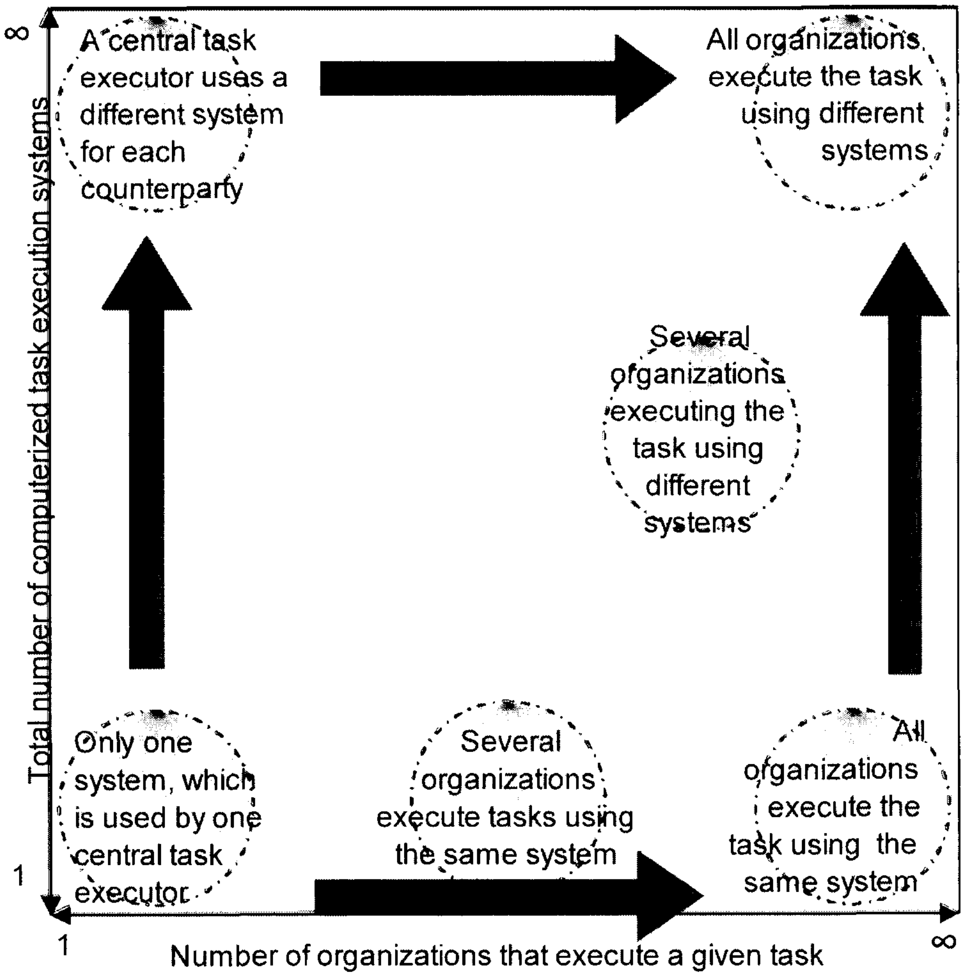

Figure 11: The task execution centralization dimension is a contraction of two dimensions

the invoicing task using different systems (top-right corner in Figure 11). In the centralized mode, there is only one party creating the invoices, using one system (bottom-left corner in Figure 11). The second dimension can also be detected by studying the TicketCorner case at the industry level (including competitors) rather than at Extended Enterprise level. Currently several ticket-selling organizations use different systems (top-right corner). However, in the past TicketCorner had installed the same licensed ticketing software as many of its competitors (implying a lower position on the vertical dimension). At industry-level, investigating the role of competitors, we notice that several organizations were executing the task using the same system. This had the disadvantage for TicketCorner the system was only changed if asked for by a bulk of the system-using companies (Pigneur & Osterwalder, 2008).

The system, therefore, missed functionalities that TicketCorner desired (such as offering packages with special rebates).

Relatively new trends such as Software-as-a-Service play an enabling role in the task execution centralization dimension and this type of centralization might become more attainable in the future.

4.4. Additional notes with respect to the IOSI Framework

This paper's main purpose is not to present 'patterns' of (proven) recurring practices for IOSI but to identify a set of dimensions of the solution space. The dimensions were extracted by studying existing solutions. Practitioners and researchers should acknowledge that each dimension refers to an important aspect and encompasses a *continuum* from an entirely centralized to an entirely decentralized setup. Furthermore, we posit that the six dimensions can be conceptualised as being orthogonal to each other. To assess the orthogonal character of the dimensions, we have performed the theoretical exercise to make an interpretation of the combination of all possible extreme positions. This involved interpreting 64 ($=2^6$) solutions. As we could give an interpretation to all of these combinations either by recognising existing implementations as occurrences of given combinations or by assessing the potential for implementation of the combination, we conclude that these (de)centralization dimensions are, at least in theory, orthogonal to each other. Including all interpretations in the text would make the text much longer without adding much value. From this exercise we can conclude that:

- Each design-solution (formed by the top row in Table 2) can – at least in theory – be combined with each execution-solution (formed by the bottom rows). In real life a strong positive correlation was detected in intra-organizational studies between the level of (de)centralization of the decision making process and the hardware (de)centralization (Ahituv et al., 1989). Similar research can now be conducted at inter-organizational level on the basis of Table 2.
- Each process-specific integration solution (formed by the left column in Table 2) can be combined with each data integration solution (formed by the right column). Companies which want to integrate their processes can choose from many ways to communicate data. For instance, instead of directly invoking some task execution with many parameters, the relevant communication material could be stored in a central shared storage space where the counterparty can retrieve it.

The IOSIF enables organizations to think out-of-the-box: they can use the IOSIF in a creative thinking process, rather than copying existing solutions. Acknowledging the dimensions are continuous and orthogonal to each other implies the number of possible solutions is countless. Many solutions have not yet been implemented. Some solutions (e.g. combining a decentralized process design with a centralized process execution control) are not obvious because they are hard to realize with the technology as it stands. Also, certain solutions are not obvious because it is not clear which of the parties would want to do the effort to realize them. Recognizing this shows interesting lines of thought for ICT providers. They could offer industry-specific shared storage spaces (e.g., for industries with many small players). Governments may also take the initiative to install a solution, for example because economic drivers would not lead to the installation of the solution that is best for society (e.g., in terms of data ownership).

Our research detected standards' specifications do not just point out all possible integration solutions. The Web services paradigm for instance largely neglects the (de)centralization concept. For example, no reference is made to how to proceed if data intermediaries (with or without a shared storage space) would be added. There is no SOAP that transmits data 'by reference', there is no non-repudiation realised by storing data in shared storage spaces, etc.

4.5. Solution properties

When developing a configuration for IOSI, organisations need to make choices along the six dimensions presented in the previous sections. In this section we review advantages and disadvantages of each choice so as to make it easier for organisations to make the right choice. The dimensions are evaluated according to the criteria defined by Goethals et al. (2008, 2011).

4.5.1. Process Design

4.5.1.1. Centralised Process Design

An important advantage of a centralised process design approach is the management of a picture of the entire process by a designated process owner. The overall picture is a vehicle to reach agreement between all parties about what the entire process should be and about the functional and non-functional requirements upon each party. In addition, the overall picture allows an easier assessment of the consequences of a party failing his task execution and of changes to the process. Furthermore, with centralised process design there are clear procedures to handle suggestions for process improvements and change requests.

The implications are that the necessary organisational structures should be put in place for the design and management of the overall picture. Local parties may be demotivated to look for changes and improvements to the process as there is a central agency that has to be involved in every process change effort and this central agency has a hard time to understand their local worries.

4.5.1.2. Decentralised Process Design

A higher flexibility and better fit to local needs are major advantages of a decentralised approach. Such an approach facilitates the local redesign of processes and allows local subtleties. Moreover, in some cases, it may even be unrealistic to assume the entire inter-organizational process can be put into a single overall picture.

The implication of a decentralised approach is that the possibilities for managing and optimizing the global process are severely reduced. Similarly, the consequences of one of the parties failing to execute some part of the process are harder to oversee.

4.5.2. Process Execution control

4.5.2.1. Centralised Process execution control

In the case of centralised process execution control, the central controller (e.g. a BPEL engine) knows the state of a case at any moment in time. Similarly, the central controller has a view on tasks that slow down the process execution and on (potential) service level violations and is able to perform load balancing.

On the downside it should be mentioned that the central controller holds the danger of a single point of failure and can become a bottleneck. Anyway, having the triggering done by a central party implies a slow down of the process because the central party first has to be informed of (and has to process) a task completion event before another party's task execution is triggered.

4.5.2.2. Decentralised Process execution control

In the case of decentralised process execution control, each party can initiate and monitor task executions so that no time is wasted informing a central controller first.

The major disadvantage of this configuration is the difficulties associated with managing the overall process. Problems with service levels and load balancing will be more difficult to manage and misunderstandings may emanate about who is to trigger which task, e.g. a customer may think that his car dealer will trigger the production of a license plate, whereas the latter leaves it to the customer.

4.5.3. Task Execution

4.5.3.1. Centralised Task Execution

In the case of centralized task execution, task execution is delegated to some central party who executes the tasks on behalf of the other parties. This has the major advantage that a single party has full control of task execution, which may be an advantage from the perspectives of quality management, and of skills and resource sharing. This, however, implies that a central party needs to be given the resources and the skills for task execution.

4.5.3.2 Decentralised Task Execution

A decentralised task execution is a natural way of working when each party desires full control of its own work. This choice may also be considered appropriate if one does not want to loose local, specialised knowledge and skills and does not wish to set up a centralized organization to execute tasks.

The downside is that it is generally more difficult and more expensive to deploy top task executors in each of the local offices.

4.5.4. Data Design

4.5.4.1. Centralised Data Design

Centralised data design has the advantage that rules with respect to data definitions, data integrity, data semantics etc. can be expressed and kept consistent by a central authority. Also, a central picture exists about what data is available and how the data are interrelated.

The disadvantage of centralised data design is that a central agency typically has difficulties to understand the exact information requirements of different users. Furthermore, for all information requirements this central party has to be involved, which limits flexibility. Policies established by the central agency may be considered rigid and inappropriate by local offices, demotivating the introduction of new information flows. Furthermore, large central budgets are often a point of contention because it is locally not clear why such amounts are being paid.

4.5.4.2. Decentralised Data Design

The main advantage of decentralised data design is a better (and often quicker) tailoring to local needs. The latter is partially induced by a better understanding of the problem domain and data semantics by the local data architects.

The drawback is that it is difficult to assess what data is currently being shared between whom within the Extended Enterprise and to avoid inconsistencies in the way data is locally stored and interpreted.

4.5.5. Data Execution – transmission

4.5.5.1. Centralised Data Transmission

With centralised data transmission, all parties have to 'talk' only to the intermediary. The intermediary can offer a 'guaranteed delivery' of messages so that data can even be transmitted if the system of the business partner is not up and running. Also, the intermediary can take care of the transformation of message formats and content (e.g., product number conversion). Formats of several Commercial Off The Shelf Software vendors may be supported out-of-the-box. All this makes it easier to add new parties to the network. Moreover, service levels can be monitored centrally.

The downside is that the central transmission infrastructure is a single point of failure. Also, local parties risk not to retain or develop knowledge and skills that are needed to deliver the benefits that are realized by the central party, creating a dependency.

4.5.5.2. Decentralised Data Transmission

With decentralised data transmission, partners only have to automate links that exist at business level, without including a central party that is –

from a business point of view – irrelevant. Companies may be more willing to share data this way because they have the impression they keep more control over who is getting access to the data.

The main disadvantage of this way of working is that if many partners need to interact with many others, it requires a myriad of bilateral agreements and mappings, which may quickly become quite cumbersome.

4.5.6. Data Execution – storage

4.5.6.1. Centralised Data Storage

Centralised data storage has a lot of advantages related to data consolidation: centralised backup facilities, security policies, service level management etc. are typically more efficient and manageable than in a decentralised approach. On the other hand, parties may be reluctant to give up control (if not data ownership) in favour of a central authority. Also, it is not always clear how costs of central storage infrastructure should be distributed over different, independent parties.

4.5.6.2. Decentralised Data Storage

The foremost advantage of decentralised data storage is that data owners have more control of their own data, which is stored locally. One can enforce one's own security levels, service levels etc. On the other hand, if many other parties need (partially) the same data, there is the risk of data duplication (and duplicated back-ups) and above all inconsistencies over the multiple locally cached versions.

5. DISCUSSION

There clearly exist many different possible IOSI solutions. The presented framework answers the two research questions. The six dimensions show a relevant classificatory basis to distinguish IOSI solutions. As we posited the dimensions are orthogonal, it is clear how the dimensions together determine a complete set of IOSI solutions to choose from, answering Research Question 2. Other researchers proposed taxonomies of different types of inter-organizational systems (Alt and Fleisch, 2001; Hong, 2002; Choudhury, 1997; Goethals, 2005; Elgarah et al., 2005; Damsgaard and Truex, 2000; Boonstra and d Vries, 2005). Those authors investigated different applications and relations between companies but did not aim to identify the many ways in which information systems can be set up to support different business practices.

Other research identified common patterns for realizing distributed applications (Schwinn & Schelp, 2003; Andersson & Johnson, 2001; Van der Aalst, 2000). That research typically focused on intra-organizational integration practices. Also, it usually aimed at showing common patterns rather than giving a continuous picture of all possible integration solutions.

Two process integration patterns which are typically used in the Web services community are 'choreography' and 'orchestration' (see e.g. Peltz, 2003). A study of our framework shows those concepts could be made clearer by acknowledging there is a difference between (1) controlling process execution and (2) managing an overall process picture (i.e., process design) (Peltz, 2003; Kavantzas, 2004; W3C, 2005; Dubray, 2005). Several dimensions are unknowingly melted together in the Web services literature, at the cost of obscuring the concepts orchestration and choreography. Moreover, one gets the message these two solutions are the only ones possible. Figure 3 shows this is a misconception.

The concept of centralization was hardly investigated in IOSI research so far, while it was considered repeatedly in intra-organizational studies. Madlberger and Roztocki (2008), did a literature review on IOSI in four leading IS journals (EJIS, MISQ, ISR and JMIS), but did *not* identify 'centralization' as one of the topics and theories that were investigated in inter-organizational collaboration research. As "the matching of [*IT structure or*] the distribution of electronic communication, processing, and storage capabilities with the needs of the firm is one of the most critical decisions of a corporation" (Fiedler, 1996 p10), it is critical to know how the centralization concept plays in IOSI.

Although the IOSIF (now it has been created) looks simple, it has the strength to disentangle B2Bi solutions into several aspects. It can be shown that making good decisions on these aspects is important because those aspects determine strategic possibilities of companies. Taking different positions on the six dimensions results in creating solutions with very different properties for organizations. For example, centralized data transmissions make it easier to connect new players, but give companies the impression they have less control over who gets access to their data, lowering their willingness to share data. Centralized process design and execution control make it easier to manage service levels, but centralized design comes with a lower understanding of local needs (and a lower motivation of locals to innovate) and a centralized execution controller can slow down the process.

6. CONCLUSIONS, LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The contribution of the paper is that it presents six dimensions on which IOSI solutions can differ from each other, and by doing so introduces the centralization concept in IOSI. The combination of the six dimensions defines a comprehensive solution space that looks simple and logical. Different solutions have different properties, with different strategic implications. It is of strategic importance if a solution is chosen in which it is easy (or not) to add new players to the network, in which it is possible (or not) to monitor end-to-end service levels, to redesign end-to-end processes, etcetera. Each business setting comes with its particular trade-offs and so there is no solution that is *the best* for all business settings. Alignment should thus be dealt with. Further research is needed to define what makes out a different 'setting' and to link settings to desired properties and to specific solutions. This paper gives a description of the solution space and it briefly illustrates how the solutions differ in terms of relevant properties defined by Goethals (2008, 2011) (such as ownership, flexibility, etc.).

The IOSI Framework reveals solutions companies may not think of without studying the framework. Standards specifications do not straightforwardly represent all possible solutions. The IOSIF solutions conceptually exist in a positivist philosophy but still have to be built in practice. Relatively new trends in the information systems field, such as Software-as-a-Service, fill positions in the B2Bi solution space in ways that were unthinkable before. Some researchers might consider the here reported research as part of a design research cycle (as discussed by Vaishnavi & Kuechler, 2006). Furthermore, grounded theory research requires theoretical sampling to identify categories (Glaser & Strauss, 1967), but statistical sampling may be more appropriate to test how often some 'theoretical categories' are actually used in specific settings. The relevance for researchers is also clear in light of prior IOSI research. Given the extensive research that was conducted towards IOSI adoption and the value of inter-organizational systems, these topics can be considered very important. This paper suggests a complementary angle to study those research topics by acknowledging that companies may have considered solutions that do not fit their specific situation. It is not unthinkable that variables such as data ownership influence system adoption and variables such as service level monitoring influence the value of the integration.

We used a grounded theory approach to derive the IOSI solution space. This method has its limitations. Constant comparison reduces, but can never completely eliminate, the risk of bias-induced distortions (Fernandez, 2004). With grounded theory it is always possible that others would have come up with different dimensions by taking a different abstraction. However, the dimensions that were identified in this paper really exist (as illustrated with the cases in Section 4) and are really relevant (as is clear from the discussion of the properties in Section 4.5). Like with all grounded research projects, the sample size is limited and future research may explore other cases that may reveal new insights. Still, we seemed to have reached theoretical saturation so there is no reason for us to believe at this moment that adding cases would learn us something new.

The framework shows practitioners the many different options they can choose from, abstracting from specific technologies. They should be aware of the solution space's richness to be able to choose an appropriate technology. A limitation of the research is that it does not include the technology itself as a determinant in the choice of integration solutions. For example, legacy systems play a role in the choice of integration solutions, but our paper does not consider this aspect. Rather, our framework disentangles B2Bi solutions into useful, simple dimensions on which solutions can be compared. Companies no longer get confronted with solutions in which they don't see distinguishable structures that can be compared. Furthermore, the framework recognizes the dimensions are continuous and are (at least in theory) orthogonal to each other, revealing the existence of a multitude of B2Bi solutions, several of which we have not seen implemented so far. For example, it is still hard to enable centralized process execution control if process design was decentralized, but research is going on to enable this. The IOSI Framework spurs organizations to think out-of-the-box. The framework also pinpoints dimensions on which central regulatory offices can intervene. Governments can set up centralized agencies to make design decisions or set up central execution systems for storage, transmission, process control or task execution which become part of the country's infrastructure. It is possible the free market does not lead to the system that is optimal for society as a whole (for example in terms of data ownership) and that government intervention is desirable.

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Nabila BOUKEF CHARKI est enseignant chercheur à ESDES et chercheur associée au DRM (UMR CNRS 7088), Université Paris-Dauphine. Docteur en Sciences de gestion (Université Paris-Dauphine). Elle a reçu le prix AIM-FNEGE Robert Reix de la meilleure thèse en Systèmes d'Information en 2005 et le prix CIGREF-AIM 2007 du meilleur article de la revue Systèmes d'Information et Management. Ses recherches portent sur la communication électronique, la virtualité et la post-adoption.

Adresse : ESDES, Université Catholique de Lyon, 23 Place Carnot, 69286 Lyon

Mail : nboukef@univ-catholyon.fr

Mohamed Hédi CHARKI est Professeur Associé à EDHEC Business School. Il a reçu son Doctorat en Management de l'Université Paris Dauphine. Ces centres d'intérêts en recherche consistent dans les Systèmes d'Information Inter-Organisationnels (SIIO), les relations inter-organisationnelles, l'adoption et la post-adoption des SIIO.

Adresse : EDHEC Business School, 24 Avenue Gustave Delory, 59057 Roubaix

Mail : mohamedhedi.charki@edhec.edu

François de CORBIÈRE est maître de conférences en sciences de Gestion à l'Ecole des Mines de Nantes. Membre du LEMNA, ses recherches portent principalement sur les systèmes d'information interorganisationnels. Il travaille plus particulièrement sur les concepts d'intégration et de synchronisation à travers l'analyse de la coordination des échanges et de ses effets, tant sur les transformations organisationnelles que sur la qualité des données.

Adresse : Ecole des Mines de Nantes, La Chantrerie, 4 rue Alfred Kastler, 44307 Nantes

Mail : francois.de-corbiere@mines-nantes.fr

Frank G. GOETHALS holds a Ph.D. in Applied Economics from the K.U.Leuven in Belgium. He is currently Associate Professor in IS and head of the IS track at IESEG School of Management (LEM-CNRS) in Lille, France. His research focuses on information sharing in B2B and B2C e-business. Frank has published in numerous journals including Data & Knowledge Engineering, IEEE Software, and Future Generation Computer Systems.

Adresse : IESEG School of Management (LEM-CNRS), 3 rue de la Digue, 59000 Lille

Mail : f.goethals@ieseg.fr

Emmanuel JOSSERAND est Professeur à HEC, Université de Genève. Il a enseigné le management et la stratégie dans de nombreuses universités et écoles en Europe, Etats-Unis, Australie et Afrique. Ses recherches portent sur les réseaux intra et inter-organisationnels et les communautés de pratiques.

Adresse : HEC, Université de Genève, 40 bd du Pont-d'Arve, Genève

Mail : emmanuel.josserand@unige.ch

Wilfried LEMAHIEU holds a Ph. D. in Applied Economics from the K.U.Leuven, Belgium (1999). He is associate professor at the Management Information Systems Group of the Faculty of Business and Economics at the K.U.Leuven. His teaching includes Database Management, Data Storage Architectures and Management Informatics. His research interests comprise distributed object architectures and web services, database systems and hypermedia systems. His research appeared in IEEE Software, Data & Knowledge engineering, and the International Journal of e-Business research.

Adresse : K.U.Leuven - F.B.E., Naamsestraat 69, B-3000 Leuven, Belgique

Mail : wilfried.lemahieu@econ.kuleuven.be

Alexandre PERRIN est professeur associé à Audencia Nantes Ecole de Management et Directeur Adjoint du programme Grande Ecole. Ancien consultant en knowledge management, il a réalisé sa thèse de doctorat à la direction du groupe Lafarge. Pour ce travail, il a reçu le

prix de thèse décerné par l'EFMD et Emerald Publishing. Membre du GREMA, ses recherches portent sur l'agenda du gestionnaire des connaissances, le transfert des bonnes pratiques et les communautés inter-organisationnelles. Les résultats de ses travaux ont été publiés dans M@n@gement, Journal of Knowledge Management, Knowledge & Process Management Journal et Gestion 2000. Il anime un blog professionnel sur les pratiques de KM en entreprise (km.typepad.com).

Adresse : GREMA Audencia Nantes Ecole de Management, 8 route de la Jonelière, 44312 Nantes

Mail : aperrin@audencia.com

Monique SNOECK obtained her Ph.D. from The Department of Computer Science of the K.U.Leuven (Belgium) in 1995 with a thesis that lays the formal foundations of the object-oriented business modelling method MERODE. She is Full Professor at the Management Information Systems Group of the Faculty of Business and Economics at the K.U.Leuven. She has been involved in several industrial conceptual modelling projects. Her research has been published in journals such as Information & Management, Data & Knowledge engineering, and Information Systems Frontiers.

Adresse : K.U.Leuven - F.B.E., Naamsestraat 69, B-3000 Leuven, Belgique

Mail : monique.snoeck@econ.kuleuven.be