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META-MODELING AND STRUCTURAL PARADIGM FOR STRATEGIC ALIGNMENT OF INFORMATION SYSTEM

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Abstract

The information system is strongly sensitive to strategic evolutions of the enterprise: organisational change, change of objectives, modified variety, new objects and business processes, etc. With the objective to control strategic alignment of information systems, we propose an approach based on our extended enterprise meta-model ISO/DSI 19440. This extension is borrowed from the COBIT framework for IT processes. In order to better lead evolutions of the information system, this extension integrates necessary structures for developing systemic tools, based on a structural paradigm. In this work we propose to build an extension of the meta-model ISO 19440, so that we can explicitly bring the issue of alignment of various aspects of the information system. The strengths of the strategic alignment are interactions and couplings between different views of the meta-model: the interaction between activities and resources, the linkage between business processes and activities, the resource interdependence of entities and objects of the enterprise, the coupling between the capabilities and resources, etc. We propose to use the COBIT best practices for driving IT processes. Thus we add the abstract concept "objective" which will be specialized. We will also add a specialization of functional entity to model IT processes. In this work, we also offer a variety of algebraic structures to establish structural measures on the information system. For each class of structure we define its role and contribution to the governance of the information system.

Keywords: *Strategic Alignment, Enterprise Object Modeling, Structural Paradigm, Systemic*

1   INTRODUCTION

The modern enterprise is a complex sociotechnical dynamic system which defines itself as an organized totality of components in interaction, according to an objective (Le Moigne 1983), (CIGREF 2002), (Vernadat 2001). It is strongly structured by computing processes responding to the various business processes. The information system guarantees communication between the effective system and decisional system as well as exchange with the environment. The information system is strongly sensitive to the strategic evolutions of the enterprise, organisational change, change of objectives, modified variety, new objects and business process, etc. According to Scott Morton (Scott et al. 1994), factors influencing the strategic orientations of an organization are briefly presented in Figure 1. In the objective to control strategic alignment of information system, we propose an approach centred on the enterprise meta-model ISO/DSI 19440 extended (ISO / 19440 2007). This extension integrates the necessary structures for developing systemic tools, based on the structural paradigm in order to better lead the evolutions of the information system. The latter is an important component of an organization and its constituents include the software, the equipment, the procedures and the persons. The information system (IS) coordinates, thanks to the information, the activities of the organization and thus allows it to achieve its objectives. It is the coordinator of the communication in the organization. Furthermore, the IS represents all the organized resources to: collect, store, treat and communicate the information.

The strategic alignment of information systems has been widely studied by researchers in the last two decades (Lederer and Sethi 1992), (Earl 1993). The research in this area includes studies prescribing methodologies and technical practices, studies describing the conceptual models, studies identifying factors of success or problems, case studies for the validation and testing of hypotheses (Brown 2004). This article is structured as follows, in section 1; we recall first the foundations of strategic alignment. In section 2, we give first of all an overview of enterprise modeling and the main works that led to the development of modeling languages. Then, we present the relations between different components of COBIT. Section 3 discusses the ISO 19440 meta-model to understand the facets of strategic alignment and integrates the structural vision for the edification of systemic tools for better management of the evolution of the information system. In section 4, a variety of algebraic structures is proposed. For each class of structure we define its role and contribution to the information system governance. The conclusion of these work places the action plan proposed in this article to highlight the contributions and limitations as well as the future investigations to be pursued.
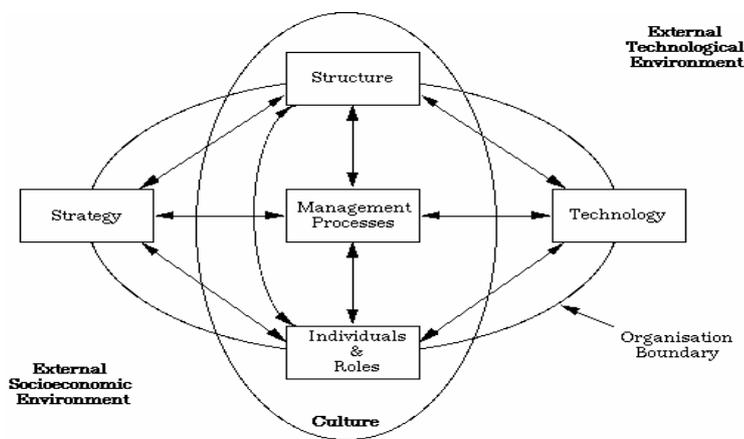

Figure 1.   Influence of the entreprise objectives (Scott et al. 1994).

2   STRATEGIC ALIGNMENT

The strategic use of information technology, better known as strategic alignment, has significantly increased due to the extreme dependence of the organization of the activities with respect to information systems and their technology supports. Strategic alignment is considered a key element to improving organizational performance in order to increase the effectiveness and efficiency and allow organizations to be more competitive in their respective industries. The term "strategic alignment" expresses the idea to establish and follow a course. This is to coordinate the strategy of the information system with the company's business strategy (CIGREF 2002). Lederer and Sethi (1992) define strategic alignment of information systems as "The process of deciding the objectives of organizational computing and identifying potential computer applications which *the organization should implement*". Other approaches define strategic alignment according to the following quotation: *"The alignment process refers to an organizational process where the mission, goals, objectives, and activities of the IS function change over time in parallel with changes in the organization"* (Henderson and Venkatraman 1999) (Ward and Peppard 2002). There are four important goals for engaging in the formulation of the strategic planning of information systems (Lederer and Sethi 1988); (Ward and Peppard 2002) :

- Alignment: identifying computer applications that could help the enterprise achieve its business goals,

 - Impact: research applications with important impact which would help the organization to gain a competitive advantage in the market,

 - Development of a flexible and cost-effective technology infrastructure,

- Development of resources and skills required to deploy the information system successfully throughout the organization.

One of the first steps towards strategic alignment is to have tools to measure it. Current approaches of evaluation, although primarily focused at the strategic levels, provide little delicacy at the tactical and operational levels, which are identified as important areas for achieving strategic alignment. Besides, most existing approaches are tested in big organizations and there is little research to evaluate the effectiveness of these approaches in small and medium enterprises. This paper offers systemic instruments, based on structural analysis, rather than focusing only on the strategic level. It also aims to measure the alignment at the tactical and operational levels.

3   ENTERPRISE MODELING

The business concept, as understood in the context of business modeling, refers to a set of organized activities implemented by sociotechnical resources in the context of an identified purpose. In such systems, the financial dimension is usually present, either in terms of gain, or rather consumption of financial resources.

We see the enterprise as a system, in the systemic sense. The enterprise is a system that operates in its environment and pursues goals (profit, power, durability ...), and organizes itself to achieve them (defining action plans, budgets…) with management and control structures. The enterprise is also a set of subsystems interacting with each other. Business modeling is an indispensable study of organizations in order to improve their performance as it can represent the company, according to an abstract multi views. It is a practice that guarantees the enterprise to be able to collect information and to intelligently pursue its objectives. Research efforts of the 1990s led to a standardized framework to meet the needs of a systemic approach of the enterprise.

Many languages and methods have been developed, such as CIMOSA (CIMOSA 1996), GERAM (GERAM 1988), IDEF (NIST 1993), GRAI (Schekkerman 2003), BPDM (OMG 2005), Standards : ISO 14258, ISO/15704, ISO/TR/10314, ENV/12204, ENV/40003. Currently, for the sake of unification, many studies contribute to the definition of a unified language for enterprise modeling (Unified Entreprise Modeling Language) (Vernadat 2001) , (Gudas et al. 2005). These modeling approaches address the organizational, informational and human aspects . For example, the standard ISO/14258, *concepts and rules for enterprise models*, (ISO/14528 2003) proposes a systemic approach of the enterprise. The standard ISO /15704 (ISO/15704 1998), *Requirements for enterprise-reference architectures and methodologies*, (ISO/15704 2005) addresses the requirements expected from an enterprise modeling architecture; the standard ENV/12204 proposes an initial specification of the necessary elements for the modeling of the following constructions «Enterprise Activity », «Business Process», «Event», «Resource», «Enterprise Object», «Object View», and «Object State».

3.1   The ISO 19440 meta-model

The ISO 19440:2007 standard specifies the characteristics of the kernel of the necessary constructions for the business modeling in accordance with ISO 19439. ISO 19440 identifies seven stages in the life cycle of models: the definition of the studied area, the definition of necessary concepts, defining business requirements, model design, implementation of the model, using the model in the operations, withdrawal or cessation of operations. It offers four views on these models the organizational view, the informational view, the functional view and the view of resources. The informational view is the representation of the Information System data. The organizational view focuses on strategy of the enterprise. The functional view focuses on the processes. The view of resources is related to the resources used by business processes of the enterprise. The ISO/DSI 19440 standard proposes a set of modeling elements to represent the company. It is oriented towards modeling by process. In this section we present the meta-model proposed

in the ISO / DIS 19440. This model is shown in figure 2; it integrates the four points of view. One area represents the border and the contents of an enterprise business or part of an enterprise. A business process represents a certain part of corporate behaviour. A business process is an aggregation of business processes and / or business activity and information described by the rules of management. The enterprise activity is to achieve a transformation of inputs to outputs by specific resources. The enterprise activity and business process collectively are called by Enterprise Function. Management rules are used to define the behaviour of a business process. They define the constraints on scheduling, and dependencies between business processes and / or enterprise activity. An event starts the execution of a business process or activity of the enterprise. A special type of class event is an order which is an instruction for the execution of an activity. Below, we briefly recall the UML diagram for the ISO/DIS 19440 meta-model.
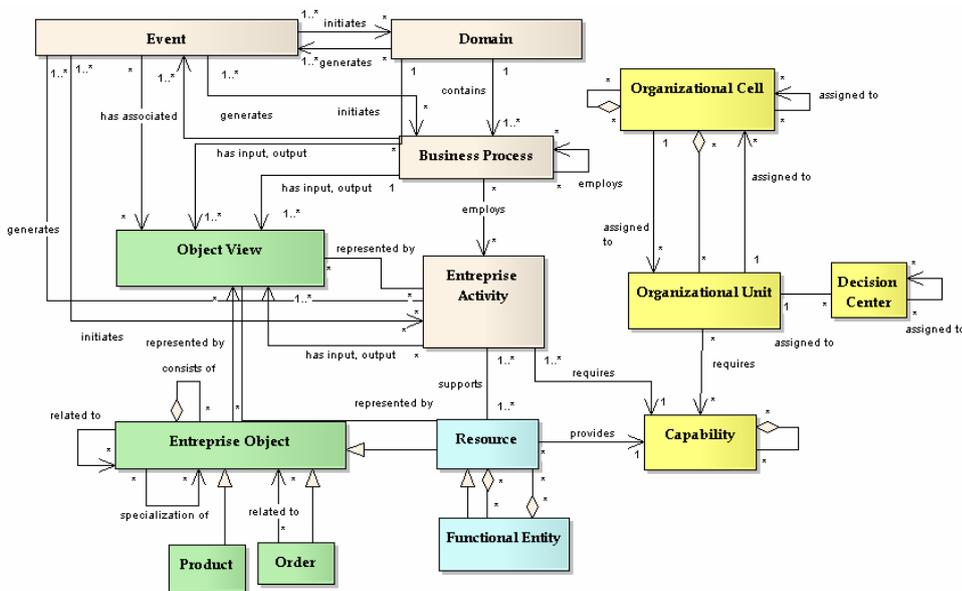

Figure 2.   *ISO/DIS 19440 Meta-model.*

3.2 The COBIT referential

The COBIT referential, (Control Objectives for Information and Technology) (ISACA 2008) was created in 1996 by ISACA (Information Systems Audit and Control Association). This referential provides a reference framework and a set of tools for controlling and monitoring the governance of the information system. COBIT is based on a set of good practices, which proposes to establish a process-oriented steering of the IS in order to contribute effectively to the alignment of technology on business strategy. The COBIT framework meets the needs of the enterprise by four major features: It focuses on the trades of the enterprise, is organized by the process, is based on checks and systematically uses measurements. COBIT components are all interconnected and aimed at meeting the needs of governance, management, control and assurance of different actors, as shown in figure 3.
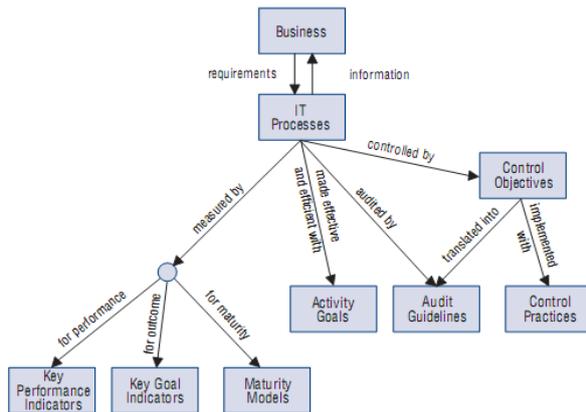
Figure 3.   Interconnexion of COBIT components.

Leaders must establish a control system or an internal control framework to enable the computer system to respond to the expectations of the enterprise. In order to achieve this, the framework for control of COBIT:

• connects with the requirements of the enterprise trades,

• Structures the computing activities within a process model widely recognized,

• identifies key computing resources to mobilize, and

• defines the control objectives to be taken into account.

The business orientation of COBIT consists of linking business objectives to computing objectives; providing the metrics (what needs to be measured and how) and the maturity models to show their degree of success; and identifying the common responsibilities of the owners of the business process and the owners of the computer processes. In summary, to provide the information that the enterprise needs to achieve its objectives, the computer resources must be managed by a set of processes grouped according to a defined logic. In section 3, we borrow from COBIT the elements of control and measures of IT processes. These elements are used for the extension of certain aspects of the ISO-19440 meta-model, extremely useful to the strategic alignment of information system.

4   EXTENDED META-MODELING

In this section we propose to build an extension of the ISO 19440 meta-model, to explicitly bring the issue of alignment of various aspects of the information system. We first develop the analysis of the structure of the original meta-model. The basic borders of alignment are at interactions and couplings between the different views of the meta-model. The interaction between enterprise business and resource shows the alignment <process, activity | resource>; the coupling business process, enterprise activity and object view relate the alignment <process, activity | information>; the interdependence of resource entities and enterprise objects defines the alignment <resource | information>; the coupling between capability and resource is called the alignment <organisation | resource>.

The structure of the basic meta-model allows the expression of the alignment of information system in the manner described above. However, the formulation of the strategic alignment in the decisional sense is not explicit in the modeling of the four points of view. We propose to use the COBIT best practices for driving the IT process. So, we add the abstract concept "objective" which will be specialized according to the point of view (figure 5).

The field of enterprise activity, business processes, activities, decision-making centers are controlled and driven by objectives (figure 6). We recall that the construct "objective" has been proposed in 19440 ISO functional aspects; however, links with decision-making centers and metric measurement are not explicit. We will also add a specialization of Functional Entity to model processes information technology (IT processes). These IT processes use resources according a well-known "information technology" (IT resource), the entity IT resource is modelled by a specialization of the resource entities (figure 4).
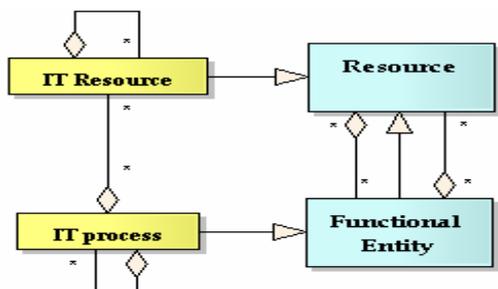

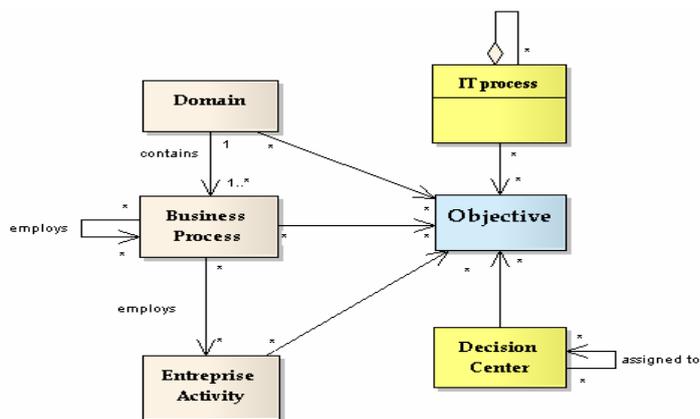*Figure 4.   Integration of IT Resource and IT process.*

Figure 5.   Integration of the objective entities.

We also add constructs indicators and metrics for measuring performance (figure 6). In figure 7, we explain structural analysis and concepts constructs derived for the evaluation of alignment with systemic tools.
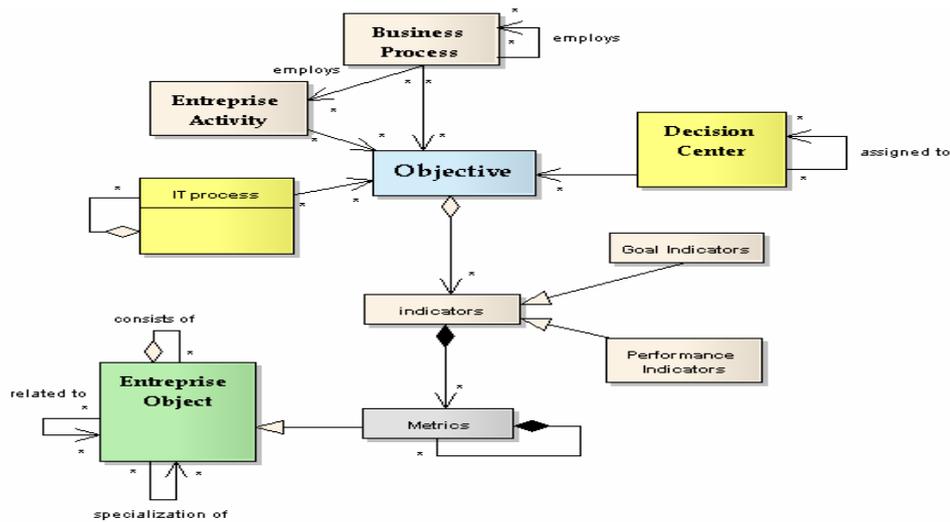
Figure 6.   *Objective and measure indicators.*

4.1   Structural paradigm and systemic tools

The systemic precepts define a system as an organized unit of elements in interaction, operating and evolving according to an objective, immersed in an environment that acts on it and on which it acts (Morin 1986), (Le Moigne 1983) . Symbolic rewriting of the definition of a system takes the following form: (S) = (E, Ri, O, Re), where E: set of all the components, Ri: set of internal relations, O: set of objectives and Re: set of external relations. This symbolic rewriting refers to the structure concept. The genealogy of the systemic has an important input from the structural paradigm (structuralism), which in its mathematical projection gave rise to several unifying structures: algebraic structures (group, monoid, dioides), structures of order (lattice), and topological structures based on the concept of neighborhood. The systemic tools that are the basis of structuralism draw their representation strengths in these three types of structures, or combination of these reference structures   (such as algebraic topology).In the best practices of the systemic, the functional structure is described by processes, a fundamental question emerges "how do processes fit together ? The structural matrices were used to give an answer to this question. The analysis of these matrices relates to networks of processes and allows study of the tree of processes, linear chains, feedback, etc. In the same vision for the various problems of IS alignment: {Organization, activity, process} × {resource}; {Activity, Process, Resource} × {information}; {Activity, Process, organization}   {Information}, we propose the construction of the structural matrices and initiate analysis permitted by appropriate structures.

The structures we suggest in this work are divided into two categories: structures that allow a single reading of the matrix structural analysis, namely the Galois lattice (order structure with closure concept) and the method Q-analysis (structure from algebraic topology) (Atkin 1974). The other category called "structural decomposition" allows prioritizing the structural matrix (order or pre-order structure). This decomposition uses the similarities or dissimilarities, coupling indices, and ranking algorithms. In this category several decomposition algorithms are referenced: analysis of similarity, minimum tree, hierarchical ascending classification, etc.. Various types of coupling can be measured: process / process coupling through resources, activity / resource link, dependency of the processes by entropic measures, information / resource link, process / objective link (table 1-3) etc.

Process

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		P_1	P_2	...	P_L
Process	P_1				
	P_2				
	...			C_{xy}	
	P_L				

Table 1.   Process coupling matrix.

C_{xy} = coupling between x and y processes.

The C_{xy} coupling can be calculated using a similarity, such as :

$$ C_{X,Y} = \frac{\left\| \varpi(X) \cap \varpi(Y) \right\|}{\left\| \varpi(X) \cup \varpi(Y) \right\|} \in [0,1] $$

Where $\varpi(X)$ The set of resources of the process X, $|K|$ denotes the cardinal of the set K.

		strategic objectives			
		O_1	O_2	...	O_N
Process	P_1				
	P_2				
	...			C_{xy}	
	P_L				

Table 2.   Process-objectives coupling matrix.

C_{xy} measuring the contribution of process x to the target y.

		Activity			
		A_1	A_2	...	A_N
Resource	R_1				
	R_2				
	...			C_{xy}	
	R_L				

Table 3.   Matrix of coupling resource $\times$ activity.

C_{xy} = "activity X using resource Y"

Other order structures can be used to address other structural tools (as the prioritization process problem). In the remainder of this section, we limit ourselves to the structural analysis by the lattice of Galois. Other tools will be considered in other future work.
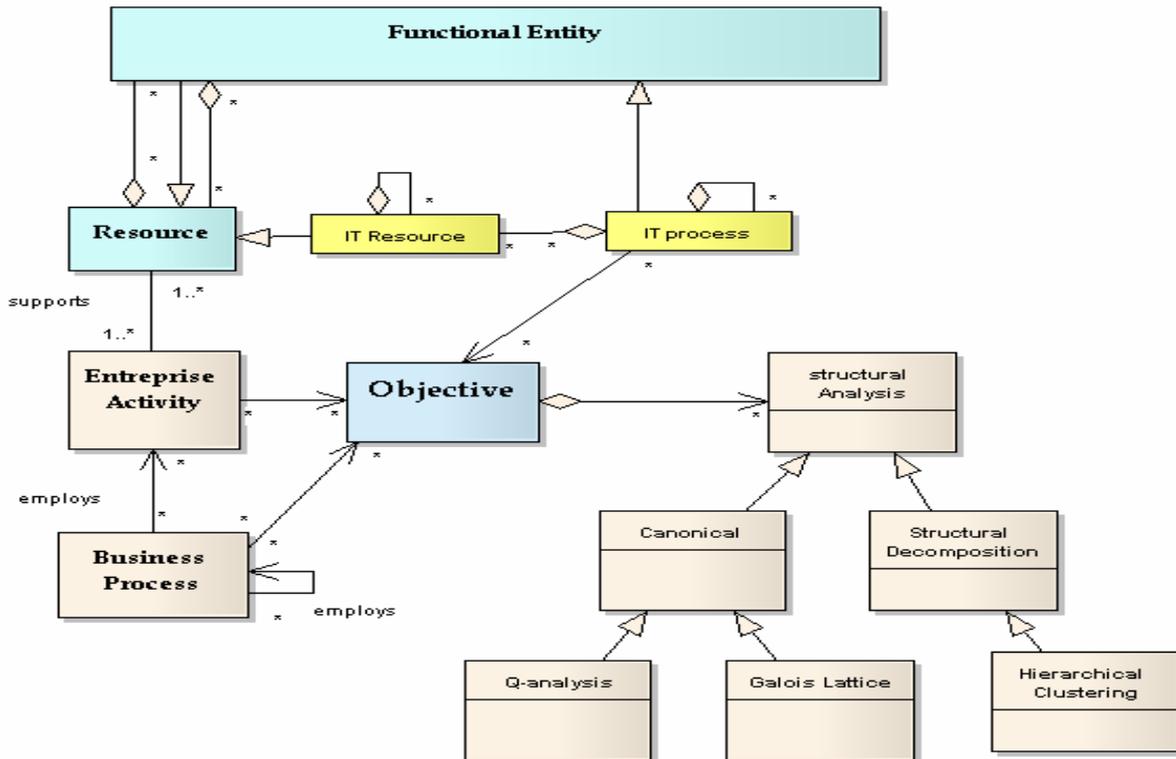
Figure 7.   Integration of structural analysis.

4.2   Analysis with Galois lattice

In this section we discuss the basics of the Galois lattice (Wile 1982), (Marghoubi et al. 2006), (Boulmakoul and al. 2007). A context C is a triplet (O, A, R) where O, A are sets and R is a correspondence. The table 4 shows an example of context represented by C= (O; A; R) with O= {r1, r2, r3, r4, r5, r6,}; A = {p1, p2, p3, p4, p5}. This context expresses that whether a resource X is used or not by the process Y.

$$
\begin{pmatrix}
 & p_1 & p_2 & p_3 & p_4 & p_5 \\
r_1 & 1 & 1 & 0 & 1 & 1 \\
r_2 & 0 & 1 & 1 & 0 & 1 \\
r_3 & 1 & 1 & 0 & 1 & 1 \\
r_4 & 1 & 1 & 1 & 0 & 1 \\
r_5 & 1 & 1 & 1 & 1 & 1 \\
r_6 & 0 & 1 & 1 & 1 & 0
\end{pmatrix}
$$

Table 4.   The binary matrix describing the correspondence R of the context C = (O, A, R).

4.3   The Galois lattice

The set L of all concepts, using the order relation $\leq$, has the mathematical structure of a lattice and is called Galois lattice L (C) of the context C. A Galois lattice is a formal concept derived from a relation R. It is a particular structure of a graph. A lattice is a directed graph without cycles and includes a minimum node and a maximal node. The lattice of Galois is a partial order induced by a binary relation R between two discrete set**s**, a set of objects O and a set of attributes A.

The Galois connection

Two functions Φ and Ψ allow expression of the correspondence between the subsets of objects P(O) and the subsets of attributes P(A) induced by the relation R. The function Φ combines all the common attributes to a set of objects Ψ , the dual function of Φ, associates all common objects to a set of attributes :

$$\Phi : P(O) \rightarrow P(A), \Phi(X) = X' = a \in A / \forall o \in X, o\Re a$$

$$\Psi : P(A) \rightarrow P(O), \Psi(Y) = Y' = o \in O / \forall a \in Y, a\Re o$$

The couple (Φ, Ψ) defines the correspondence of Galois between sub-sets of objects P(O) and attributes P(A) of context.

Galois closure

A closure on an ordered set (E,) is an application that checks for all the following properties:

- $x \leq \Re(x)$ ($\Re$ is extensive)

- si $x \leq y$ alors $\Re(x) \leq \Re(y)$ ($\Re$ is monotone increasing)

-si $\Re(x) = \Re(\Re(x))$ ($\Re$ is idempotent)

An element x of E is closed for $\Re$ if and only if $x = \Re(x)$

The compositions h=$\Phi\partial\Psi$ and h'=$\Psi\partial\Phi$, are closed operators of Galois connection. The operator $\Phi\partial\Psi$ generates closed sub-sets of objects while the operator $\Psi\partial\Phi$ generates closed sub-sets of attributes.
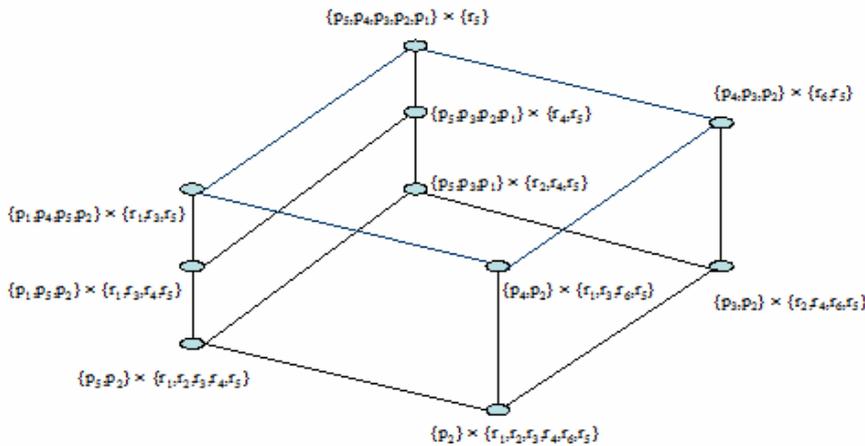

Figure 8.   *Galois lattice for the context given in table 4.*

In a maximum di-clique (A, B) (a closed set in the Galois lattice), B is the set of all resources used at the same time by all the process of A; no other process can use them all.

The structure of the Galois lattice can be used for dividing the enterprise into an informational domain. We can define a domain as an activity or set of activities based on a set of common information and having little interaction with other activities (table 3).

With this simple example (Figure 8), the lattice representation of processes in relation with the resources is canonical. A single reading is allowed with this diagram. Gutman scales can be used to show classifications. With this same structure and with methods of generation of association rules from data mining, it is possible to generate associations between processes.

These associations express dependencies between processes, the meta-processes. We get for example two associations of high confidence 100% p5→p2 et (p4,p5)→p1.

5   CONCLUSION

In this paper we have brought new construction**s** to extend the ISO 19440 meta-model, to grasp the various facets of the strategic alignment of information systems, and assess alignment with systemic tools derived from structural paradigm. We have shown how the Galois lattice structures can be used in this context. Other structures have been discussed in this work and are the subject of our current research. Admittedly, this work emphasizes only fundamental aspects; we have put in place a strategy for deployment of elements contained in this work on real sites (public and private organizations). We believe that implementing this type of practice would be of great interest to engineering information systems. We have set up suite of software solutions, implementing the tools proposed in this work. These software solutions will be very useful for the testing and the validation of the effectiveness of our approach for a real case.

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