CENTERIS - International Conference on ENTERprise Information Systems / ProjMAN - International Conference on Project MANagement / HCist - International Conference on Health and Social Care Information Systems and Technologies

Analysis approach for enterprise information systems architecture based on hypergraph to aligned business process requirements

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Abstract

Modeling is the artifact of the outcome of some designing and analysis activity. Our idea is to present a formal way to use the mathematical analytic methods for exploring misalignment based on different concepts (information systems (IS), enterprise architecture (EA) business processes (BP)...) and relationships between various concepts in the domain of Enterprise IS (EIS) and try to align BP requirements.

This paper presents a description of an analytical approach based on hypergraph representation for EA based on hypergraph theory. The hypergraph as a mathematical structure is very flexible thereby it offers the opportunity for unified and uniform handling of models and providing solutions for representing various views and perspectives of the functioning enterprise exploiting the service of IS.

Keywords: Process modelling,entrprise information systems architecture, hypergraph, business process, information system.

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1. Introduction

In most organizations, it is impractical to make a fully articulated business model and IS architecture because of the most recently rapidly changing business environment [1] and thereby originated adaptivity requirement against business IS which led to the agile business approach as a management science philosophy.

EA is the construction of an enterprise described by its entities and their relationships, it is defined as an organizing logic for BP and information technology (IT) infrastructure in order to check, maintain and control the whole operation of an enterprise.

IS represent a major investment for any firm in today's business environment to achieving business goals, for that, it should support organization systems which represent the fundamental elements of a business (people work process tasks structure and control system) during any decision.

The rest of the paper is structured as follows: the second section introduces theoretical background about EA, IS, BP, IT and the relationship between those concepts, after that in section 3, provide the impact of changes on a last various concept defined before. We outline a brief definition about hypergraph and its theory in the fourth section, the in section 5 we try to propose our idea and explain our main goal using hypergraph representation, finally, we will close the ideas and future work in the conclusion

2. Theoretical background

The theoretical foundation of the paper consists of two parts, first we will give some basic definitions and concepts related to IS, EA, BP and IT. The aim of the definitions is in order to get the relation between them easily in the second part of this section.

We start with IS's definition mentioned which in various references as below:

Definition 1: "IS is the study of complementary networks of hardware and software that people and organizations use to collect, filter, process, create, and distribute useful data, typically in organizational settings" [2] [3].

Definition 2: "ISs are interrelated components working together to collect, process, store, and disseminate information to support decision making, coordination, control, analysis, and visualization in an organization" [4]

The five components of IS are: hardware, software, data, people, and process. The first three, fitting under the technology category, but the last two, people and process, are what separate the idea of IS from more technical fields, such as computer science. The IS play a big role in an organization which can be expressed by its components, one of the most its roles to take data and turn it into information, and then transform that into organizational knowledge [5].

IS is becoming more and more integrated with organizational processes, bringing more productivity and better control to processes. The last component of IS is the process, which is a series of steps undertaken to achieve a desired outcome or goal which described as activities that are performed to create, deliver, and support a product or service. businesses looking to effectively utilize IS do more. Using technology to manage and improve processes, both within a company and externally with suppliers and customers is the ultimate goal. Technology buzzwords such as "BP reengineering," "BP management," and "enterprise resource planning" all have to do with the continued improvement of these business procedures and the integration of technology with them. As question posed: "what ways do processes have a role in business?". A process that is focused on achieving a goal for a business. For BP concept is defined as:

Definition 3: "A BP is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer". BP modeling tools allow representing processes in a digital way that can then be transferred to a live automated process" [6].

EIS is a critical component of organizations [7]. Companies strongly rely on their EIS in integrating and executing their processes across the organization, their business network? Enterprise systems provide a high level of computer automation to support organizations 'several key business functions [8]. EA hasn't been well defined and agreed upon, it's being developed to support IS development and enterprise reengineering.

Definition 4: "An EA, therefore, shows the primary components of an enterprise and depicts how these components interact with or relate to each other. An EA is a conceptual framework that describes how an enterprise is constructed by defining its primary components and the relationships among these components" [9].
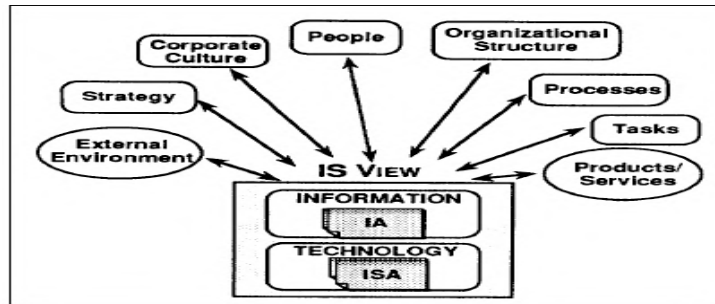
Fig. 1. Information Systems View of the Enterprise Architecture

EA is a capability to envision, plan, design, lead, manage and control organizations, systems and/or processes in current, transitionary, and future states, and the relationships between them. It describes an organization in terms of its strategy, structure, information flows, value streams, as well as it is business and transaction models [10]. EA enables the business to understand its current composition, utility, costs, and sources of value generation [11][12][13]. It improves the quality and performance of BP and enhances productivity across the organization by unifying and integrating data linkages.

Beside the different analysis and design model for IS that underlie of BP Models and workflow, the concept of an architectural approach which plays a relevant role can be used in model creation. The various architectures for IS have been used to assist in understanding the relationship between the different perspectives, aspects, components and single models [14][15][16]. Zachman architectures developed for IS in an enterprise, TOGAF is developed by Open Group for software systems within companies. TOGAF method contains two main parts: The Architecture Development Method (ADM) and the Foundation Architecture with generic functions/services on which specific architectures and building blocks can be built.

Business analytics is "the use of data", IT is a major force bursting on to the enterprise scene and it must address in the discussion of managing and using IS. IT strategies must be linked with business strategies .IT refers to the software, hardware, IS that enable and support process activities. As indicated, the assessment of IT as one of the BP management (BPM) core elements is structured in a similar way to that of BPM methods and refers to the process lifecycle stages [17]. IT solutions for process design and modeling cover the (semi-)automated support that enables derivation of process models from log files (process mining) [18].

3. Impact of deferent changes on IS and BP and EA

As we motioned in the background that there is a strong relation between IS and process because it is one of the most important components and any influence impact both of them, all enterprises systems are builds around BP [19][20], different factors can make changes in the enterprise systems, those factors those factors could: environment, resources, data, activities of the process …[21], those factors impact more the architecture of enterprise EA, changes occurred at the operational level of the organization as a result of the enterprise system implementation too [22], for that reason of influencing it should be able to focus their attention on all those impacts, The proposal is to extend the BP approaches with an organization and planning level according to Zachman Framework [16] thereby an "analysis season" is created beside the "design season" and "operational season" [8].

In our previous work [12], we propose an approach where the data and business structure (operational level and design level) is expanded with an analysis phase (organizational and strategic planning level) to observe and to detect business events that enforce changes in process, many of the operational changes that occur in the organization they studied [19], the impact of those changes on the activities of various actors within the organization, and the causes of both success and failure. This research provides for understanding the impact of the process in specific organizations and identifying the factors that affect its successful, it does not provide a basic understanding of the long-term impact on individuals or organizational behavior resulting from the fundamental changes in the organization and its processes.

On the other hand, those changes occur within the organization (i.e., changes in BPs) as a result of the enterprise system implementations [23] and those changes profoundly affect various aspects of organizational behavior.

As we explained that a lot of factors could impact EA and IS with its processes specially the environment for that we need a strong understanding of the business and find solutions to drop this impact or to get optimal business performance, on the other hand to high performance of the implementation for that reason we are trying to find a solution for those impact factors.

4. Hypergraph as a sound ground representation

In this section we will introduce the basic theoretical background of the hypergraphs, especially the generalized hypergraphs provide a flexible structure to describe complex relationships that can be explored among models during analysis and design of IS [24].

Definition 5: A hypergraph is a pair (V, E) of finite set $V = \{v_1, \ldots, v_n\}$ and a set E of nonempty subsets of V. The elements of V are called vertices; the elements of E are called edges. The generalized hypergraph allows that hyperedges as nodes can be included in other hyperedge but the contained hyperedge should be different from the container hyperedge [23].
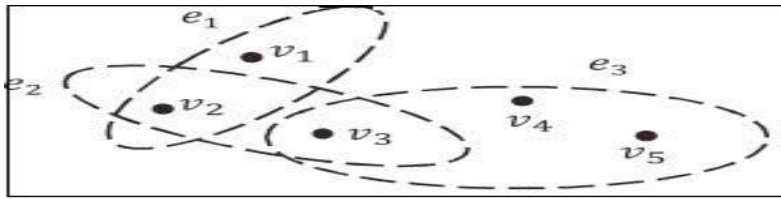

Fig. 2. Hypergraph structure.

Definition 6. A generalized or extended hypergraph is that some of the hyperedges are denoted – in certain cases – as vertices, thereby a generalized hyperedge e may consist of both vertices and hyperedges as well. The hyperedges that are contained within the hyperedge e should be different from hyperedges e [24].

Definition 7. Directed hyperedge (hyperarc) is an ordered pair $E = (X, Y)$ of (possibly empty) disjoint subsets of vertices; X the tail $T(E)$ of E while Y is the head $H(E)$ [23]

A hypergraph is a generalization of an ordinary graph, let $G(V, E, w)$ denote a hypergraph, where V denotes a finite set of nodes v, E denotes the set of hyperedges e, w is a weight function defined as: $w : E \Rightarrow R$. Each hyperedge $e \in E$ is a subset of V and is assigned a positive weight $w(e)$ [25].

Definition 8. A forward hyperarcs (F-arc) is a hyperarc $E = (T(E), H(E))$ with $|T(E)| = 1$, A backward hyperarcs B-arc, is a hyperarc $E = (T(E), H(E))$ with $|H(E)| = 1$. A Forward -backward graph (or BF-hypergraph) is a hypergraph whose hyperarcs are either B-arcs or F-arcs [26].

Definition 9. A directed path P_{sd} from a source s to a destination d in H is a sequence of nodes and hyperarc $p_{sd} = v_1 = s, E_{i_1}, v_1, E_{i_2} \ldots, E_{i_q}, E_{q+1} = d$ where: $s \in T(E_{i_1})$, $t \in H(E_{i_q})$. P_{sd} is said to be a cycle, when $t = s$ [27].

Definition 10. Let a hypergraph $H = (V, E)$, s and t two distinguished nodes, the source and the sink respectively. A cut $Q_t = (V_s, V_t)$ is a partition of V into two subsets V_s and V_t such that $s \epsilon V_S$ and $t \epsilon V_t$ given the cut Q_{st} [28].

5. Hypergraph based representation for IS and EA

As the literature proves before, EA supports the BPs at conceptual, system analysis and logical design viewpoint. In the other side the graphs as a representational structure are apt to system modeling, analysis and specification, especially IS. The representation should accurately describe the states of systems and keeping up the isomorphism between its structure through graphs and map the flexible representation for the system being investigated.

The hypergraph is one of the most general and strong graph for representing relationships. This mathematical tool has specific features and consequences of graphs that proved by theorems, for example, the correctness of mapping

can be checked by test algorithms for isomorphism. The validity of transliteration of systems into graph representation is critical for exploiting the available mathematical toolset to model both the dynamical and static facet of systems as e.g. operational semantics, re-configurations, controls, security and the model transformation in analysis and design.

The processes within IS are derivatives of BP which actual use of them is described by scenarios. The treatment the BP model and workflow side and the end-user/ organization side IS Models make possible to link the process and end-user perspectives with the documents that are transporters of data and information, the document's structure has some correlation with the structure of the organization which should be correspondent to development team to produced architecture.

The EA frameworks offered a comprehensive view, it is defined as a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, BP, IS. So, BPs should be aligned with delivery and management processes in order to optimize business performance, the central idea in this paper is to represent, or model (in the abstract) an orderly arrangement of the components that make up the system under question and the relationships or interactions of these components which the goal of architecture.

The using of hypergraph notion with the different vertices for the various component (concepts) of IS (Enterprise) and arcs for interact with or link them. The goal is to including EA with various mathematical proprieties of hypergraph in order to attend hypergraph-based architecture description, the work based on the hypergraph theory to describe the relationship in EA. we used the hypergraphs as a tool for describing IS from various viewpoints yields a formal method to analyze the system and check the conformance, compliance, and consistency of the set of models.

A generalized hypergraph that consists of vertices and hyperedges represent the whole IS, the different vertices or nodes of the hypergraph correspond to an element of the system as BP or document. The arc or edge of the hypergraph expresses the notion of relationship between nodes (two nodes i.e. binary relationship). The relation between a different subset of nodes related with hyperedge, the edges in a hypergraph the so called hyperedges can group together more than two vertices. The generalized hypergraph yields the opportunity that a hyperedge can be perceived as a vertex and be a component of other hyperedges as a node.

From the hypergraph theory we can say that it makes a good understanding of enterprise either commercial businesses or government organizations are faced with a range of challenges recently, these challenges impact the architecture of the enterprises, also contentious changes in the environment such as changes in the economy, society, physical environment, economics, culture, and politics. For that reason, enterprises should be able to react and to focus their attention on all those impacts and finding the best ways to react a flexible way for the external stimuli that appear in the form of business events.

In organization generally, a lot of difficulties encumber the achievement of alignment. So the analyzing step (detecting, correcting and preventing misalignment) is important to achieving alignment since it helps to solve the problem of revealing the typical symptoms of changes happened around the organization and the changes in process execution, for that the use of the hypergraph-based approach to describe an EA will help to get a framework for developing and implementing an enterprise information architecture aligned with business requirements [21] in another hand to giving ways to automatized and algorithmic.

6. Conclusion and future works

EA provides a well-developed approach to aligning organizations and their use of technology and provides alignment across BP and organization design - operationalizing work and job designs, EA is the capability that is best positioned to support changes that drive business innovation and digital enablement. Many organizations view their EISs as a core component of their business for that it should be aligned with the best approaches. Our literature analysis showed that EA, IS and BP linked with a strong relation between them and any influence on one of them makes a misalignment could impact the organization. This paper defined the basics concepts of EA and the purpose and utility of an EA and its place in the IS environment are discussed.

The approach presented provides a formal way to use the mathematical analytic methods for exploring misalignment based on different concepts and relation between them. As future work the proposed hypergraph-based modeling and representing approach provides the opportunity to check and control the discrepancies in complex EAs

Acknowledgements

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