On the Changing Role of Enterprise Architecture in Decentralized Environment: State of the Art

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***Abstract*—The problem of business-IT alignment is of vital significance for modern enterprises. Solving it allows all components of an enterprise to operate together in a collaborative manner for the purpose of maximizing overall benefit to the enterprise. Enterprise Architecture (EA) is a discipline that aims to surmount mismatches of business and IT in a holistic manner from the ground up through proper design.**

Decentralization of organizations and subsequent change of their management and operation style requires major changes in organization processes and heavily involves the IT. This paper demonstrates, however, that EA is primarily aimed at centralized organizational structures, and as such has shortcomings when being applied to decentralized organizations. Overcoming these deficiencies requires some new principles to be introduced and incorporated into EA knowledge. Relevant sources for these new principles are decentralized organizations, peer-to-peer technologies, and organizational science. All these areas have tackled the problem of decentralization in certain ways. This paper presents prevalent decentralization principles, and how they have the potential to be applied to EA.

***Keywords*-Enterprise Architecture, Decentralization, Peer-to-Peer**

I. Introduction

Organizations with rigid centralized management style fail to sustain dynamic environments due to their inertia in decision making and lack of agility. Political, social and economic systems progressively transform to distributed network, and novel organization forms accordingly are emerging [1]. The terms like "proactive enterprise", or "liquid enterprise" coined recently, describe the nature of such organizations. Transparent or dynamically changing boundaries, agile processes, interactions aligned with real-time business goals, virtual collaborations, all of those are technology-enabled capabilities of emerging organization forms.

In [2], organizational structure is defined as "... institutional arrangements and mechanisms for mobilizing human, physical, financial and information resources at all levels of the system..." Decentralization of organizations and subsequent change of their management and operation style requires major changes in organization processes and heavily involves the IT.

While emerging technologies serve as the main catalyst for organizational transformations, utilizing the right technologies and evolving thus to digitized business processes to automate organizations core capabilities [3] - is primordial for organizations.

Traditionally, such questions are addressed by the enterprise architecture (EA) discipline. EA *"defines the underlying principles, standards, and best practices according to which current and future activities of the enterprise should be conducted"* [4]. EA methods and tools serve:

- to specify the current state of the company's foundation for execution [3] - *architecture as is*;
- to identify the target architecture *architecture to-be*;
- to analyze the business-IT gap, to set up a *master plan* and to define *architectural principles* for achieving the target architecture.

These produced artifacts (architecture as-is, to-be, architectural roadmap and principles) are often addressed in literature as EA description; the process that organization has to execute in order to obtain its EA description is called EA method (Fig.1). A traditional EA project, though, consists in implementing an EA method and producing an EA description. To assure that the organization will continuously follow the principles and achieve the designated goals after the termination of the EA project the third element has to be defined. We call this element EA engine, referring to its capacity to stir the company. [1] The de-facto EA methodologies rely on organizational properties such as centralized management, global company identity, etc. that are getting obsolete with progressive decentralization. Consequently, implementation of these methodologies in decentralized organization becomes difficult and inefficient and the role of EA as a driver for IT transformations is getting compromised.

As an example, consider a public organization acquiring a software system with an objective of integrated facil-

[1] In [3], this element is addressed as "engagement model".

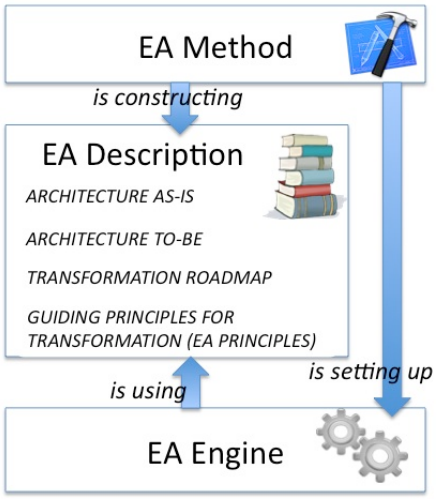

Figure 1. Enterprise Architecture

ity management (room reservation etc.) spanning across divisions costing thousands of euros. Divisions were not involved into decision making process and product evaluation (due to centralized strategic planning including IT planning) and eventually refused to shut down their local systems and switch to the global one (due to decentralized IT management). As a consequence, strategic initiative for integration failed; divisions managed to protect their interests (preserving local systems that are tailored for their needs) however got charged for the acquired system they never used (due to centralized budgeting). This example demonstrates a mismatch between the architecture principles (tendency towards integration), architecture engine (the process of prioritizing, evaluating and eventually deciding on the global system to adopt) and the organizational structure that inherits some centralized mechanisms while being strongly decentralized.

Therefore, novel EA processes, principles and concepts are needed to both handle the ICT resources and to foster business/ICT co-evolution in decentralized environments.

In this paper, we analyze various forms of organizational structures presented in the literature, outline the characteristics of decentralization and identify the challenges related to decentralization in organizational IT. We define decentralization in organizational IT as a continuum with three phases: Centralized IT, Federal IT and Decentralized IT. The main contribution of this paper is an assessment of the three prevalent EA methodologies (TOGAF, Zachman and FEA) and their capacity to support the decentralization along this continuum. This assessment is finally leading us to a set of recommendations for decentralized-aware EA.

The reminder of this article is organized as follows: In Section II, we discuss the role of EA in organization and provide an overview of three EA methodologies: TOGAF, Zachman and FEA; in Section III, we discuss different forms of organizational structure (generic and related to organizational IT) presented in the literature focusing on their degree of centralization/decentralization. We outline the main characteristics of decentralization and highlight the challenges related to decentralization in IT. In Section IV we examine how the EA methodologies presented in Section II support decentralization. In Section V, we propose a set of recommendations for decentralized-aware EA.

II. Enterprise Architecture and EA Modeling Frameworks

A. A Common Perspective on Enterprise Architecture

While there is no singular agreed-upon definition for EA, different definitions[4], [5], [3], [6], [7], [8], [9] do have much in common. EA is a discipline that takes a holistic, design-oriented approach to transforming high-level business vision and goals into the integration of an enterprise's organizational structure, business processes, and information systems. This transformation involves identifying and implementing the necessary change for this to occur. In order to view different Enterprise Architectures from a common perspective, this paper will break the frameworks down into three separate components: the EA method, the EA description, and the EA engine.

The Method aims to lay the groundwork for the EA project. Typically, this involves setting up teams, ownership, responsibilities and gaining commitment. Also it defines the overall process of collecting, validating and approving the EA artifacts (e.g. descriptions As-Is, To-Be, gap analysis, principles) that will form the second component - The EA description. The Engine involves setting up a support structure for ensuring the ongoing adoption of the to-be EA description. This can involve gaining commitment from stakeholders, setting up some compliance checking procedures, and deciding upon a prioritization of tasks to be completed. The remainder of this section will look at three different EA frameworks from the perspective of of these three phases: The Open Group Architecture Framework (TOGAF), the Zachman Framework, and the Federal Enterprise Architecture (FEA).

B. TOGAF

The Open Group Architecture Framework, more commonly know as TOGAF, is a freely available EA framework created by The Open Group[2], a consortium of IT organizations. TOGAF is comprised of a number of different aspects, mainly: the Architecture Development Method (ADM), "a method for developing and managing the lifecycle of an enterprise architecture" [9, Ch. 5.1]; the Architecture Content Framework, a companion to the ADM which describes the content of the products of the ADM; and the Enterprise Continuum, which provides a means to organize the produced architectures.

[2] www.opengroup.org

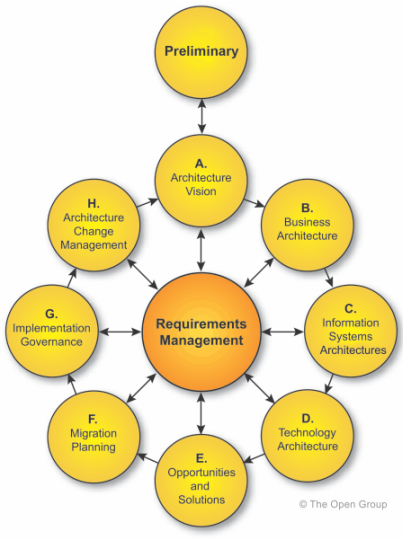

Figure 2. TOGAF: ADM basic structure from [9, Ch. 5.2.2]

1) EA Method: The TOGAF ADM falls under our EA Method component of EA. The TOGAF ADM is made up of a preliminary phase, six core phases (labeled A-H), and a requirements management component.

In TOGAF, the preliminary phase lays the groundwork for the rest of the EA process. Some important aspects are to set up a governance structure and EA team for the EA process and to establish a repository for storing all architectural information [9, Ch. 6].

Phase A of the TOGAF Process, the architectural vision phase, is aimed at setting a clear vision for the enterprises future architecture. This involves creating the initial as-is architecture as well as setting clear, management approved goals and requirements, and transforming them into a high-level vision of the enterprises to-be architecture [9, Ch. 7].

At this point, TOGAF suggests that the outputs of the preliminary phase and phase A be organized into a "Statement of Architecture Work". This document is to be approved by project sponsors [9, Ch. 7.4.11] and can be used to form the basis of a contract between the architecture provider and the client [9, Ch. 36.2.20].

The next three phases, B-D are concerned with creating the as-is and to-be business architecture, information systems architecture, and the technology architecture. TOGAF suggests two different approaches to creating the architectures: baseline first or target first [9, Ch. 19.4]. Baseline-first involves analyzing the as-is architecture for areas where improvements can be made. Target-first aims at creating a detailed target architecture and then mapping it back to the as-is architecture in order figure out what needs to change. The main aspects of these phases are to develop the as-is and to-be architectures, analyze the gap between them, and create an initial road-map of the steps needed to cross the gap.

Phase E and F, Opportunities and Solutions and Migration Planning, are concerned with organizing the work to be done into projects, and then creating a schedule for executing the projects [9, Ch. 13-14].

The final ADM phase, phase G, is concerned with the implementation and setting up a framework for its governance and its compliance to the target architecture [9, Ch. 15].

2) EA Description: TOGAF views architecture from the perspective of four different architecture domains [8]: business, application, data, and technical. Business architecture is concerned with processes and functions used to meet business goals, application architecture is concerned with the design of specific applications and their interactions, data architecture is concerned with managing enterprise data, and the technical architecture is concerned with the infrastructure (hardware and software) used to support the applications. The architectures in these four domains are created through the ADM phases B (Business Architecture Phase), C (Information Systems Architectures Phase) and D (Technology Architecture).

The various architectural artifacts in TOGAF are organized across an Architectural Landscape [9, Ch. 20.2] of three dimensions: breadth, level, and time. Breadth refers to the area of subject matter for an architecture. Levels refer to the level of detail of an architecture. TOGAF specifies three levels of detail: strategic, for overall direction setting at the executive level; segment, for architectures at the level of a program or portfolio; and capability, for architectures concerned with how the architecture process is itself enabled and governed. The time dimension of the landscape keeps the state of architectures as they evolve over time. Additionally, the Architecture Landscape can be partitioned into independent partitions for supporting different organizational units [9, Ch. 40].

At each level of the Architecture Landscape, architectures are further organized through the Enterprise Continuum which provides a way to organize the architectures from generic to organization-specific [9, Ch. 39]. The most generic are called Foundation Architectures [9, Ch. 39.4.1], which are applicable to all enterprises. A core aspect of a Foundation Architecture is to provide a high-level taxonomy which can provide a basis for the more specific architectures [9, Ch. 43]. TOGAF includes a Foundation Architecture which can be used, called the Technical Reference Model(TRM). The second set of architectures in the continuum are called the Common Systems Architectures [9, Ch. 39.4.1]. These architectures are specific to a generic problem domain (e.g. security management), and are thus applicable to a wide range (but not all) of enterprises. TOGAF includes a Common System Architecture for the domain of information integration, called the Integrated Information Infrastructure Reference Model (III-RM). The third set of architectures in the continuum are called Industry

Architectures. These architectures are applicable to a specific problem within a specific industry. They are thus useful to many members of that industry, but not necessarily outside of it. The most specific level in the continuum are Organization-Specific architectures. As the name implies, they are relevant only to a specific enterprise. These outline the architectural solution for a particular enterprise and provide ”a means to communicate and manage business operations across all four architectural domains” [9, Ch. 39.4.1].

3) EA Engine: TOGAF outlines an ADM phase concerned with the ongoing change management process for the architecture of an enterprise. It is concerned with managing changes to the architecture throughout its lifecycle [9, Ch. 16]. In this phase, a governance body sets criteria for determining if a change requires an architecture update if a new cycle of the ADM needs to be started. An important aspect of this process is to deploy tools for monitoring for business and technological changes and measuring performance indicators.

TOGAF describes a formal review process for determining compliance. The main goal of this process is to ”[f]irst and foremost, catch errors in the project architecture early, and thereby reduce the cost and risk of changes required later in the lifecycle” [9, Ch. 48.3.1].

TOGAF outlines a formal approach to architecture governance which involves the setting up of an “Architecture Board” [9, Ch. 47]. The TOGAF Architecture Governance Framework [9, Ch. 50] suggests guidelines for developing a formal governance structure for the Enterprise Continuum (and thus, all the architectural artifacts) and architecture processes.

C. Zachman

The Zachman Framework was the first EA, first introduced by John Zachman in 1987 [8], [10]. It consists only of a taxonomy, and as such only fits into the EA Description aspect of EA.

1) EA Description: The Zachman Framework breaks down EA into a grid of perspectives. Each perspective is characterized by two things; its target audience and the issue is aimed at. ZF covers six issues: What (data and entities), How (functional), Where (locations and interconnections/networks), Who (people relationships), When (events and performance criteria), Why (motivations and goals) [4]. For each issue, it views it from six different perspectives: executive, business management, architect, engineer, technician, and enterprise users.

The executive perspective is meant for executives or planners and needs to provide an estimate of a system’s functionality and cost [4]. The business management perspective is a business view of how an owner thinks the business operates [11]. The architect perspective takes a systems viewpoint and describes the operations and interactions of the variety of systems in an enterprise. The engineer perspective views describes the physical technology and design of the individual systems. The technician perspective takes the perspective of a ”sub-contractor” who is implementing a specific system and the high, out-of-context level of detail associated with that. The enterprise users perspective describes the perspective of the system users.

D. FEA

The Federal Enterprise Architecture (FEA)is an effort by the federal government of the United States to create an EA for the entire government. The FEA is a complete EA framework, covering all three components of EA. The Federal Enterprise Architecture Program Management Office describes FEA as “...a common language and framework to describe and analyze IT investments, enhance collaboration and ultimately transform the Federal government into a citizen-centered, results-oriented, and market-based organization as set forth in the President’s Management Agenda.” [12] FEA takes takes an approach where individual organizational units develop their own architectures that fit into an overall framework of common standards and interoperability.

FEA is composed of six core elements [8]:

- The organization is broken-down into different segments of varying scopes, and architecture is developed for each segment
- A set of five reference models which are used as a basis to describe the important elements of the FEA in a consistent manner
- A process for creating each segment EA
- A transitional process for moving from the current state of the enterprise to the visioned state
- A taxonomy for organizing the various assets of the FEA
- Guidelines for measuring the degree of success of the FEA

Compared to TOGAF and Zachman Framework, FEA defines both the taxonomy for EA artifacts (EA description in Fig. 1) and the EA process for creating these artifacts and using them by organization (EA method and EA engine in Fig.1).

1) EA Description: FEA develops architecture for segments and enterprise services. A segment is a “major line-of-business functionality” [8] for an individual organizational unit (such as an agency or department). Two types of segments exist: core mission-area segments and business service segments [12]. Core mission-area segments are at the scope of a single organizational unit (though they may be shared by different units) and are essential to its purpose [8], [12]. Business service segments are also at the scope of an individual organizational unit, however these segments exist in all organizational units and are defined for the entire enterprise. Like business service segments, enterprise

services are defined organization-wide. However, they are different in that they also function at the enterprise level, e.g. a single security management service that is shared by the entire enterprise.

The EA artifacts defined by FEA include baseline segment architectures, target segment architectures and transition strategy. The EA transition strategy describes the overall plan and schedule to achieve the target ("to-be") architecture.

In order to have a common language for describing the enterprises assets, FEA describes five reference models for mapping assets to segments and enterprise services [12]. The five reference models are the performance reference model, the business reference model, the service component reference model, the technical reference model, and the data reference model.

The performance reference model provides a framework for developing consistent measurement. The business reference model provides a framework for developing a functional view of the enterprises line of business. The service component reference model provides a framework for describing how the services offered by IT systems support business functionality. The data reference model provides a framework for describing data in a consistent way that enables enterprise-wide sharing.

2) EA Method: FEA defines a four step iterative process for creating architectures for each segment and service [12]:

1) Architectural analysis
2) Architectural definition
3) Investment and funding strategy
4) Program management plan and execute projects

The first step, architectural analysis, is concerned with defining the scope of the segment, its baseline architecture, current problems in the segment, and a high-level vision of the desired final state for the segment [12].

The second step, architectural definition, is concerned with defining the detailed target architecture of the segment [12]. Aside for the architecture itself, it is also necessary to define a roadmap of projects to get there, the segment transition strategy, and the performance goals of the architecture.

The third step, the investment and funding strategy, is concerned with specifying how the projects identified in the segment transition strategy are to be funded [12].

The fourth step, program management plan and execute strategies, is concerned with making detailed plans for the individual projects, executing the plans, and defining performance measurements for the initiative [12].

3) EA Engine: FEA describes an "engine" to maintain the architecture in order ensure that it stays relevant over time. FEA calls this engine an activity it calls "segment architecture maintenance" [12]. In this activity, it is important to monitor for, list and prioritize new architectural change drivers as they appear. The impact of these drivers needs to be defined.

FEA defines a EA value measurement process - "a continuous, customer- focused process relying on feedback from EA stakeholders and other value measures to increase the quality and effectiveness of EA products and services to support business decisions." [12] - Section 5.

III. Organizational Structure and Decentralization

This section will first discuss the forms of organizational structure defined in the literature. Second, the (de)centralization of current organization and, as a consequence, their styles of IT governance will be explored. We conclude this section by underpinning the challenges organizations have to face due to their progressive decentralization.

A. What is a Decentralized Organization?

An organization can be structured in many different ways. Sachdeva [2] defines organizational structure as "... institutional arrangements and mechanisms for mobilizing human, physical, financial and information resources at all levels of the system..." According to Jacobides [13], "Organizational structure provides the frames through which individuals see their world. Thus, the way each organization is structured shapes an ecology of different, distinct frames that exist at the level of the organizational sub-unit."

There has been a lot of research on specific forms of organizational structure. Taxonomies of organization forms are defined in [14], [15]. *Classic* and *modern* types of organizational structure are often recognized. Classic types include simple centralized organizations [16], bureaucratic organizations [17], divisional structure and functional structure. Modern types include matrix structure, flat organizations, adhocracy. New forms of organizational structure emerged recently: collaborative networks, virtual organizations and coopetition.

According to Robbins [18], organizational structure has three components: complexity, formalization and centralization. Complexity refers to the degree to which activities within the organization are differentiated; Formalization refers to the degree to which work is standardized; Centralization refers to the degree to which decision making is concentrated at one point in the organization.

Following Luthens [19], centralization and decentralization can be also defined according to three factors: geographical or territorial concentration or dispersion of operations, functions, extent of concentration or delegation of decision making powers. In [6], the following characteristics of centralization are defined: the allocation of decision rights, the structure of communication lines and the choice of forms of coordination.

In a centralized organization, all decision making authority would reside with a single, top-level authority. In a completely decentralized enterprise all members would have equal decision making rights. Here, hierarchy manages

the interdependencies between the different sub-units of organization and often makes direct interactions and communications unnecessary [20]. Decentralized organizations instead have less formalized communication lines [6], and more fluid, project oriented teams. [21]

Centralized organizations lean towards primarily vertical style of coordination [22], which is characterized by formal authority, standardization and rules in operations and in IT, and planning and control systems. Decentralized organizations lean towards lateral coordination characterized by meetings, task forces, coordinating roles, matrix structures, and networks [22].

Below, we will consider popular forms of organizations focusing on their degree of centralization.

B. Forms of Organizational Structure and Decentralization

1) Classic Organizational Structures: Pearlson and Saunders offer a thorough description of a pure hierarchical organization structure [6]: Except for the top level position, each position has one superior and zero or more subordinates. Decision rights and communication lines are strictly defined and work their way down from the top (i.e. the centre). The scope of a position is specialized and strictly defined by your superior and one works in assigned teams. The primary benefit of a hierarchy is that the high levels of management have strict governance and control over the company. Hierarchical organization structures are suited for stable, certain environments.

Hierarchical organizations an be subdivided into simple centralized and bureaucratic organizations:

In simple centralized organizations, both strategic planning and operational decision making authority belongs to one person at the top. This structure can be found in small and single-person-owned organizations with only two hierarchical levels.

Bureaucratic organizations [17] are characterized by multi-level hierarchical structure and use of standard methods and procedures for performing work.

Hierarchical organizations generally divide their labor either in terms of function, a grouping of common activities, or in terms of division, a grouping based on output (product). Two organizational structures (Divisional structure and Functional structure) can be identified accordingly.

2) Modern Organizational Structures: Matrix structure is another popular style of organization structure [6] that can be seen as a mixture of functional and divisional structures. In this form, individuals are assigned two or more supervisors covering different (usually product and functional) dimensions of the enterprise. Pearlson and Saunders state that matrix organization structures are suited for dynamic environments with lots of uncertainty, presumably because their authority structure allows them to cover multiple aspects when making decisions. However, like a hierarchical structure, a matrix structure is a rigid construct with strictly defined roles, communication lines and decision rights. Authority still comes from the top in a centralized manner, even though it becomes more distributed among matrix managers at the lower levels [6].

Flat organization is a novel type of organizations where only one or maximum two hierarchical levels are defined (similarly to simple centralized organizations). For example, Valve Corporation, a software company in the video game industry released their handbook in 2012 [23]. Unlike simple centralized organization described above, individual employees have complete freedom despite there being a president/founder at the top: Nobody reports to anyone, and everyone is free to work on whatever they want to. This is an example of high decentralization.

Adhocracy [21], [6] aims to discard traditional hierarchies in favor of decentralized decision rights and flexible communication lines connecting the entire enterprise. Specifically, instead of hierarchies, an adhocracy has a rapidly changing set of project oriented groups that have decision making authority and other powers [18]. Mintzberg describes an adhocracy as ”a loose, flexible, self-renewing organic form tied together mostly through lateral means” [16].

3) Post-Modern Organizational Structures: New forms of organizational structure enabled uniquely by modern information and communication technologies Internet emerged recently: collaborative networks [24], virtual (boundaryless) organizations and coopetition [25].

Related to the idea of adhocracy, is the concept of collaborative networks (CN). Camarinha-Matos and Afsarmanesh define collaborative networks as being composed of ”a variety of entities (e.g., organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their: operating environment, culture, social capital, and goals.” [24] Three common characteristics in various CNs are autonomy in the individual entities, a drive towards meeting common or complementing goals, and the use of an agreed-upon framework for collaboration.

Virtual organizations and coopetitions differ from the organizational structures defined above since they do not represent a single legal entity but a group of autonomous and independent entities with different (and possibly concurrent) strategic goals. These entities are engaged into collaboration in response to a specific market situation customer demand etc. Heterogeneous structure of such organizations remains invisible for a customer, whereas the service level agreements should be maintained at the equally high level as for any other organization. Such organization structures are grounded on a sustainable collaboration between partners without any centralized control.

Virtual organization is a group of independent organizations working together to achieve some goal(s); virtual communities, a community of individuals that interact with each other through the use of computer network-based technologies; and virtual breeding environments, a group of

organizations that set up a framework for inter-operability in order to enable the potential for forming a virtual organization [24].

Another organizational form emerged recently is coopetition. Bengsston and Kock describe coopetition as a complex relationship between firms where they simultaneously compete and collaborate and benefit from both [25]. Coopetition allows the participating organizations to take advantage of a heterogeneity of resources. Organizations may seek to create competitive advantage through a unique resource they own (e.g. skill). At the same time, it might be beneficial for them to cooperate with another organization that possesses a unique resource that is of value to them.

4) Decentralization in Organizational IT: According to Rockart et al.[26], changes in business and technology as well as progressive decentralization of organization as a whole drives the changes in roles and structure of IT units. The works presented in [27], [28], [26], [29] focus on the relation between the structure of an organization and its IT.

Fulk [27] discusses the interplay between communication technology and various organizational forms. The authors consider communication technologies as one of the key enablers of interorganizational and intreorganizatiohal changes.

In [28], authors study how different organizational forms affect the knowledge transfer in organization. They claim that "Organizational forms enable different kinds of motivation and have different capacities to generate and transfer tacit knowledge."

Weill [29] defines six forms of organizational structures in IT (called IT Governance archetypes) based on how the five major IT decisions in organizations are made. These archetypes are: business monarchy, IT monarchy, feudal, federal, IT duopoly and anarchy. In a *business monarchy* all IT related decisions are made in a centralized manner by the top-level executives (e.g. the CxOs). In an *IT monarchy*, a group of IT professionals are responsible for making the decisions. This is also highly centralized as the authority resides with this group. An *IT duopoly* is characterized by two groups, one of IT executives and the other of business executives, coming to agreements in order to make decisions. This is more centralized than the federal form, as the decisions are only made by the two groups, rather than each individual business unit having input. The *feudal* is much less centralized. It is where individual organizational units are responsible for their own decisions. *Federal IT* would aim to balance these through a combination of central IT and IT in the business units. *Anarchy* is a highly decentralized style of governance. It is similar to the feudal archetype, however the size of the units is much smaller. Instead of being an entire business unit, small teams or even individuals are responsible for their own decisions.

Figure 3 maps the organizational forms presented above to the centralization axis, ranging them from highly centralized (e.g. bureaucratic) to decentralized (e.g. virtual organizations)

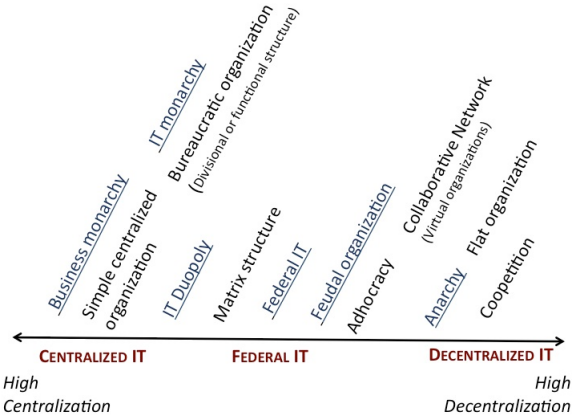

Figure 3. Organizational taxonomy: From Centralized to Decentralized

We agree with Rockart, Earl and Ross [26], who describe a continuum of IT governance styles ranging from centralized to decentralized, with federalism in the middle. Indeed, many organizations today tend to combine both centralization and decentralization in order to obtain the advantages of both styles: global integration and efficiency due to centralized management in some key areas and agility and high quality of local customer services due to decentralized decision making in others.

For the purpose of our study, we consider three types of organizational structure in IT: *Centralized IT*, where all IT related decisions are made in a centralized manner by the top-level executives, *Decentralized IT*, where each organizational subunit manages its IT in completely autonomous and independent manner, and *Federal IT* that can be seen as a combination of central IT management and IT management in the subunits. Here a primary task would be to maintain standards for the entire enterprise while supporting flexibility on the subunit level. The business units would still have ownership of many of their own systems, allowing them to implement them as they deem best.

C. Challenges of Progressive Decentralization in Organizational IT

Modern organizational structures show a strong tendency towards de-centralization [30].

However, this transformation is not a mere question of "flattening" the organization by shifting authorities and decision making power from top to bottom hierarchical levels or from one person to a group. In classic organizations, not only hierarchy ensures the control and coordination, it also manages the interdependencies between the different subunits of organization and often makes direct interactions and communications unnecessary [20].

Therefore, the main challenge related to decentralization and "weakening hierarchy" is a lack of interaction and communication between organizational subunits.

Caruso, Rogers and Bazerman [31] highlight the importance of information sharing and coordination for these organizations. In order to succeed at these aspects, they outline three barriers that decentralized organizations need to overcome. The first barrier is intergroup bias; the tendency to treat one's own group better than other groups. The second barrier is group territoriality; the tendency for a group to protect their territory (physical or informational). The third barrier is poor negotiation strategies used by different groups when interacting with one another.

Decentralization of organizations and subsequent change of their management and operation style requires major changes in organization processes and heavily involves the IT. According to [26], the major risk of IT decentralization is ***lack of synergy and integration due to a lack of standardization.***

Enterprise Architecture is a discipline that allows an organization to construct and evolve its IT according to its needs. It provides methodology and sets up structures for assessing current state of IT (architecture As-Is), for planning, agreeing upon and communicating its future state (architecture To-Be) and for carrying out this transformation. Though, it is important that EA methodology and structures acknowledge progressive decentralization and help the organization to tackle the challenges related to it.

In the next section we examine how progressive decentralization in IT is addressed by current EA practices.

IV. Existing EA Practices to Support Decentralization: Analysis and Shortcomings

The field of Enterprise Architecture (EA) emerged in order to combat two increasingly prevalent problems facing enterprises: system complexity and business-IT alignment [8]. As enterprises rely more and more on information systems of increasing complexity, these problems become even more important. The field of EA views the solution to these problems to be one of concurrent design. It is not enough simply try and fit IT to the business; business and IT aspects should be designed concurrently.

A. TOGAF

1) Concepts supporting a centralized organization:

EA Method and EA Engine: TOGAF outlines a formal approach to architecture governance which involves the setting up of an Architecture Board "to oversee the implementation of the [architecture] strategy" [9, Ch. 47]. This board has an important role in Architecture Governance, such as "[p]roviding the basis for all decision-making with regard to the architectures" [9, Ch. 47] and enforcing architecture compliance.

Architecture board concept suits well for the organization with strong centralization in IT (Centralized IT to Federal IT in Fig. 3. Having a single entity responsible for high-level decision making fits in with the concept of a Centralized IT organization. TOGAF does suggest that the board has enterprise-wide representation [9, Ch. 47] which may support some level of decentralization, however it suggests the representation comes in the form of "senior managers"; a concept primarily from traditional organization structures.

Throughout TOGAF, references are made to the existence of a bureaucratic or hierarchical centralized structure in place:

For example, an important part of the preliminary phase [REF] is to set up a *formal governance framework* for all architectural material, a concept that is related to the rigid forms of traditional organizational structure.

Another example: after the completion of "Phase A: Architecture Vision", TOGAF requires approval of the current vision of the architecture. This requirement of approval assumes the existence of someone with a higher level of decision-making authority to give approval.

A third example is an entire set of architectures at the strategic level of the Architecture Landscape which is meant for the "executive level" [9, Ch. 20].

EA Description: TOGAF suggests the development of architecture principles that "...define the underlying general rules and guidelines for the use and deployment of all IT resources and assets across the enterprise" [9, Ch. 23]. Having a central set of principles that is to be applied to an entire organization supports centralization.

TOGAF includes the concept of an Architecture Repository, which is to hold the entirety of the Architecture Landscape in addition to other architecture-related information. The idea of a single place to store all information is highly supportive of centralization.

2) Concepts supporting decentralized organization:

EA Method and EA Engine: TOGAF primarily supports some level of decentralization through the concept of *partitions*. It suggests dividing the Architecture Landscape into separate parts in order to support multiple architecture teams working concurrently and conflicting architectures in different organizational units. This enables "federated architectures independently developed, maintained, and managed architectures that are subsequently integrated within an integration framework" [9, Ch. 40.3].

Furthermore, "[f]ederated architectures typically are used in governments and conglomerates, where the separate organizational units need separate architectures" [9, Ch. 40.3]. This supports the idea of different organizational units developing their own individual architectures. The mechanism for integrating the individual architectures under the roof of the corporate architecture is not explicit.

TOGAF additionally indirectly supports decentralization through the suggestion that the entire TOGAF process be *tailored to fit the needs of the enterprise*. This is done in the preliminary phase of the ADM. In theory, this would allow TOGAF to support any kind of enterprise. The guidelines provided for this, however, are minimal.

B. Zachman

1) Concepts supporting centralized organization:

EA Description: The Zachman Framework aims to model a complete enterprise in a single, "periodic table of elements" [32]. It attempts to break down an enterprise into a matrix of 36 elements, with alignment and composite integration relations defined between these elements.

The perspectives of Zachman Framework line up with a bureaucratic organizational structure: the defined views (from executive to user) constitute an explicit organizational hierarchy. Clear separation between domains make this framework suitable for matrix organizations as well.

The lack of flexibility in definition of domains and views and the requirement to fill in the matrix - is perhaps the Zachman Frameworks main shortcoming with respect to decentralization. A primary aspect of decentralized organizations is their high level of flexibility. For a decentralized organization where both roles and domains are not uniformly defined (implicit) for sub-units, the use of the Zachman Framework becomes difficult if at all possible.

EA Method and EA Engine: Providing a schema for organizing architectural artifacts of an enterprise, the Zachman Framework does not imply any particular method for collecting these artifacts (what we call EA Method in Fig. 1). Neither is suggests the set of structures that we call EA Engine.

Therefore, tailoring and implementation of Zachman framework for a concrete organizational structure depends on experience of the EA (consultancy) team.

To summarize, the Zachman Framework provides a detailed taxonomy of EA artifacts that supports a hierarchical view on the organization. The application of this framework in decentralized (flat, adhocracy) organizations remains unclear.

C. FEA

1) Concepts supporting centralized organization:

EA Description: Through the use of a common set of *reference models*, FEA prescribes standards that are to be followed throughout the organization. This limits the flexibility that the individual organizational units have and makes this framework suitable for bureaucratic organizations with a high level of standardization of its processes.

In FEA, however, individual organizational units have the freedom to develop their own architecture as long as it fits in to the set standards. This supports some level of decentralization and suits to organizations with federal structure, where individual units have input into decisions.

EA Method and EA Engine: Segment architecture development is defined by FEA as a collaborative approach conducted by an integrated project team (IPT) comprising business subject matter experts, enterprise architects and technical subject matter experts. FEA defines a set of segment architecture stakeholders and their roles (Table 2-2 in the document [12]) in segment architecture development. For example, the role of senior management is defined to set the agency strategic goals; chief architect and EA team are appointed to supervise the architecture development process, coordinate the activities of other stakeholders and communicate and share the information between segments when needed; IPT activities and meetings are coordinated and managed by a Program Manager. The Program Manager should monitor progress, evaluate segment architecture completion and demonstrate results. These roles naturally line up with the centralized to federal organization of IT (Fig.3).

According to FEA, "Stakeholder commitment must be attained to support each step in this [development] process.." [12].

The mechanism for integrating the segment architectures under the roof of the corporate architecture is assured by specific governance and management processes, which are, tough implying different stakeholders, remain centralized.

All steps of segment architecture development involve/supervised by the Program manager and/or chief architect or Capital Planning and Investment Control (CPIC) lead, pointing on centralized management and budgeting.

Transition strategy is defined for the agency level though it is assessed on the global level. Governance-wide collaboration and reuse based on standards is outlined by FEA as an important part of RA transition strategy.

2) Concepts supporting decentralized organization:

EA Description: The resulting segment architecture is positioned by FEA as a shared vision for business and IT transformation within a core mission area or common service. Each segment can have its own architecture that responds to its business needs.

EA Method and EA Engine: The development of *segment architectures* is described as a collaborative process between EA architects and other stakeholders. The accent is placed on the "reconciliation" of the segment architecture with an agency architecture and cross-agency initiative, emphasizing the importance of cross-agency collaboration, common opportunities and initiatives.

Architectural analysis and architectural definition steps of segment architecture development involve business owners at the agency level who define business and information management requirements for the segment. This allows to ensure the local, agency-level interests within a corporation.

FEA is targeting the groups of independent federal agencies with an objective to increase their inter-operability and quality of service they are offering for citizens. Among three EA methodologies considered in our study, FEA is the only one recognizing the need of inter- and intra-agency cooperation and communication. Nevertheless, many of the concepts on which the EA method and EA engine of FEA are grounded remain strongly centralized. Again, this supports our initial claim.

Table I
EXISTING AND PROSPECTIVE SUPPORT OF PROGRESSIVE DECENTRALIZATION BY EA FRAMEWORKS

EA component:	**Existing support for centralized organizations**	**Existing support for decentralized organizations**	**Applicable P2P principles for a solution**
EA Method:	Approval process based on hierarchy; architecture development is coordinated, supervised and evaluated by well-defined roles in a company (e.g. senior managers define strategic goals); EA teams coordinate architectural work and communicate results; results are controlled and evaluated centrally - by program manager)	Federated architectures; possibility to adapt ADM for a specific organization; architecture development process involves multiple stakeholders	peer production principles for creation and evaluation of EA artifacts; P2P trust management replacing approval mechanism
EA Description:	Strategic level architectures; hierarchy of architecture principles; a common set of reference models; hierarchical organization of EA artifacts with explicitly defined roles and domains (Zachman)	Architecture partitions; architecture reference models; segment architecture; the concept of "shared vision"	User-driven content submission and change management of the content (i.e. the structure is defined by the users)
EA Engine:	Architecture board; formal governance framework; common set of principles for entire organization (i.e global commitment is taken for granted); centrally managed architecture repository	integration of various (segment) architectures is assured by (centralized) management and governance	Peer production for relevance/accreditation (e.g. decision making in budgeting, strategy, opportunity evaluation, solution evaluation); user-driven content submission and change management of the content; P2P trust management

V. TOWARDS DEFINITION OF DECENTRALIZED EA

The challenge of decentralization is not a new one; other efforts have been able to address their view on it with success. The specifics of the challenge varies between domains, however there may exist general principles that can be taken and applied to EA.

One such effort is peer-to-peer architecture. According to Saroiu, Gummadi and Gribble, peer-to-peer systems "...typically lack dedicated, centralized infrastructure, but rather depend on the voluntary participation of peers to contribute resources out of which the infrastructure is constructed. Membership in a peer-to-peer system is ad-hoc and dynamic..." [33].

We argue that peer-to-peer is a relevant concept to decentralization in EA for two reasons. First, individuals in highly decentralized organization are able to contribute to the enterprise in a manner that is completely up to them. This is similar to peers in a peer-to-peer system, where the peers participate in a completely voluntary manner. Second, the challenge that peer-to-peer systems overcome is similar to the main challenge faced by decentralized organizations. Saroiu et al. state that the challenge of peer-to-peer systems is to "to figure out a mechanism and architecture for organizing the peers in such a way so that they can cooperate to provide a useful service to the community of users" [33]. This is similar to the main challenge facing decentralized organizations–a lack of interaction and communication, or in other words, cooperation–which was identified in Section III-C.

With EA being a potential solution to this challenge of decentralization in organizations and the parallels between the domains of peer-to-peer systems and decentralized organizations, we propose that peer-to-peer may be a potential source of principles that could form the basis for evolving current centralization-focused EA frameworks into ones that are supportive of decentralization. This section will briefly present and discuss two relevant principles from peer-to-peer.

A. Peer production

Benkler defines peer production as "...production systems that depend on individual action that is self-selected and decentralized, rather than hierarchically assigned" [34]. Here, individuals act according to their own will rather than being directed by a central figure. Peer production works on the idea of the individuals willingly coordinating with one another by expressing their own views while understanding the views of others.

Peer production takes many different forms. One example are user-driven media sites such as Reddit[3] and Slashdot[4], which follow a peer-production model for producing "relevance/accreditation" [34] on user-submitted content. On these sites, the users have the ability to vote on the submitted content in order to decide on the content's relevance or credibility. Another example of relevance production are crowdfunding sites such as Kickstarter[5] where individuals decide on the funding of user-submitted projects by giving their own money. Peer production is also used to produce content, such as in the case of Wikipedia[6], an online ency-

[3] www.reddit.com
[4] www.slashdot.org
[5] www.kickstarter.com
[6] www.wikipedia.org

clopedia which provides a platform for user-driven content submission and change management of that content.

If we view enterprises as being composed of peers (a peer could be individual or an organizational unit), the idea of peer production becomes useful for EA. For example, the EA Engine of TOGAF relies on an Architecture Board responsible high-level decisions and governance. Instead of a central board responsible for making decisions, a model based on the principle of peer production for relevance/accreditation could be used instead. This would better support decentralization as decision making would then be distributed amongst the peers that make the organization.

B. Trust management in peer-to-peer

Due to the fact that peers in peer-to-peer systems are able to operate in a completely independent manner, there exists the problem of knowing whether or not the contribution made by a peer is trustworthy or not. Consequently, some researchers have proposed various methods for determining trust in a peer-to-peer environment. For example, Aberer and Despotovic [35] have proposed determining whether a peer is trustworthy or not based on a peers history of interactions with other peers in the system. This assessment is performed by the individual peers, and as such, is appropriate for a peer-to-peer environment. TOGAF employs the idea of an approval process grounded on the presence of centralized authority. This is to ensure that the presented architectural material is in fact valid for the enterprise. In a decentralized environment, this central authority is not likely to exist. Peer-to-peer trust management may offer a solution here. Instead of being give an explicit stamp of approval, the acceptance of a peer's contribution to EA by other peers can be based on a peer's level of trustworthiness.

VI. Conclusion

In this study we have analyzed the problem of non-fit between emerging decentralized organizational environments, and established EA methodologies aimed to model organizations and specifically their linkages between business and IT.

We have argued that modern organizations show strong tendencies toward decentralization in their organizational structures and thereby IT governance by following different patterns, having in common the fostering of entirely new relationships between business processes and IT, and how IT resources are managed. The classification of organizational forms of IT presented in Section III, was used to assess if the dominant EA methodologies can support them.

Current EA frameworks, which provide methods to set up organizations' IT architecture, management and evolution, fail to solve this major concern in decentralized environments by helping organizations to address the challenges related to changes required for, or issued by IT. We have surveyed Zachman Framework, TOGAF and FEA, and concluded that the first is unable to support any significant aspect of decentralization, and while the latter two provide some basic flexibility in TOGAF, it is mainly facilitated by the ability to have a different architecture for organizational units and by providing space for new methods for the architecture development; in FEA, the conclusions are similar, while the top-level organization standards need to be obeyed by all units. Consequently, implementations of these methodologies are heavily limited to promote, or even support new decentralized organization patterns fostered by virtual organizations, collaborative networks, coopetitions, and others. Lastly, we discussed how the application of specific principles from the concept of peer-to-peer architecture–in particular peer production and P2P trust management–could be projected onto the problem of employing EA in organizations following a decentralized organizational pattern.

The aim of this research is to contribute to a state-of the-art on enterprise modeling methodologies by analyzing the decentralization of organizations and supporting business patterns and technologies, and thereby the consequences of this trend to the requirements for new approaches to IT resources, namely, their use and management. Regarding future work, our next steps involves contrasting the presented theories and argumentations empirically, i.e. by mapping them to EA of different organizations. Such an ongoing study concerns an organization in the public sector of Sweden, exposing many of decentralized behavior as discussed in this paper.

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