Work Systems based Fractal Architecture of Information Systems

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Abstract. Contemporary information systems have to satisfy needs of agile and viable enterprises. They shall include mechanisms of business intelligence, business process management, information technology infrastructure management, and alignment between business and computer systems. The mechanisms for business process handling and computer systems handling are similar, and the mechanisms for their continuous integrated improvement also are similar, therefore the architecture of information systems components that support these processes can have a measure of similarity if considered at a particular level of abstraction. The paper, focusing on aforementioned similarities, uses St. Alter's work systems paradigm for constructing fractal architecture of information systems that can be used for supporting agile and viable organizations.

Keywords: work system, fractal architecture, information systems.

1 Introduction

Cloud solutions and use of business intelligence tools have transformed the landscape of information systems from relatively rigid internal architectures to more flexible and open structures of information handling [1], [2]. This refers to more flexible distribution of physical devices as well as possibility to acquire real time data that can be used for introducing changes in business and information technology solutions. The question arises how these abilities of information technology solutions can be represented in information systems architectures so that complexity that increases with the introduction of higher variability and flexibility could be embraced and managed.

While business, software, and hardware systems are very different, the mechanisms used in their analysis and management do not differ so much. For instance, similarities can be found in the actor based approaches in business analysis and actor based approaches in parallel programming. Moreover, according to our experience [3], [4] - data acquisition and analysis methods for big data analysis in social networks can be compared with similar methods in computer networks. These similarities suggest to seek for common architecture patterns that could be used in business and information technology domains, since the information systems processes cross both domains.

In this paper we propose to use work systems paradigm introduced by St. Alter [5], as a basis for reflecting architecture of information systems. Taking into consideration that information systems concerns both business and information technology subsystems of an enterprise, we use inclusion relationship between different work systems of the enterprise

The paper is structured as follows. We briefly discuss related work in Section 2. In Section 3 we propose the work systems paradigm based model of fractal information systems architecture. In section 4 we discuss the benefits of viewing information systems architecture as a fractal architecture composed of multiple work systems. Brief conclusions and directions of further research are presented in Section 5.

2 Related Work

The approach proposed in this paper is based on two main sources of related work, namely, on the work systems theory [5], and contemporary applications of viable systems model [6], [7], [8].

According to Steven Alter [5] "an information system is a work system whose processes and activities are devoted to processing information, that is, capturing, transmitting, storing, retrieving, manipulating, and displaying information. A work system is a system in which human participants and/or machines perform work (processes and activities) using information, technology and other resources to produce specific products and/or services for specific internal or external customers". The customers can be external customers of the enterprise as well as internal customers (one sub-work system has produced information valuable for another sub-work system). The work system is embedded in its environment, and depends on organizational strategy and infrastructure (see Fig. 1).

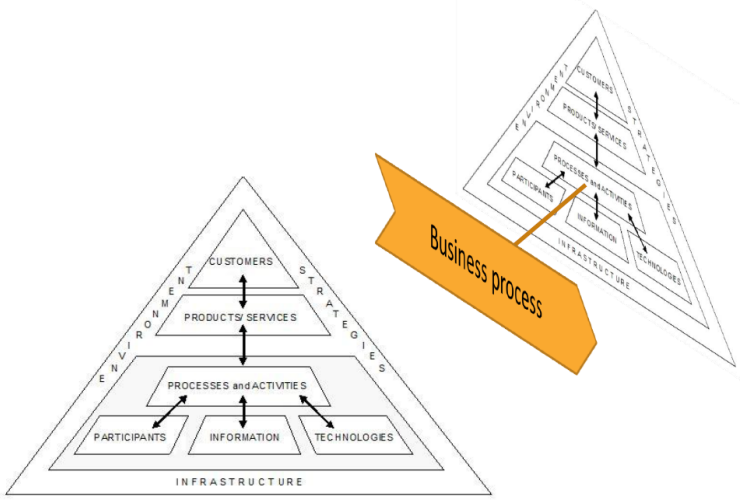

Fig. 1. Work system behind the process (the triangle in the figure is adopted from [5])

Thus, we can state that behind each organizational process there is a work system. From the modeling perspective, there is a real or virtual work system behind of each business process at any level of abstraction or decomposition. On another hand, for each business process there can be find an information processing sub-process (or activities that themselves perform a transformation of inputs into outputs and therefore can be regarded as processes, which produce information). Thus, using Alter's work system paradigm it is possible to identify information systems architecture that consists of work systems that are structured according to the chosen model of representation of business processes. This issue will be discussed in more detail in the next section.

Contemporary applications of viable systems model show that an enterprise has to handle its internal work systems as well as it has to have good environment scanning capabilities at the operational and strategic levels [6], [7], [8]. For the enterprise to be viable, its internal units have to have a measure of autonomy and it should be organized as fractals [9] (in Fig. 2 each "ONE", which corresponds to the processes that bring value to the customer, consists of a smaller scale viable systems model). Such structure enables flexibility that is essential to ensure agility of enterprises. Thus, according to the viable systems model, for the value adding and strategic processes of the enterprise (processes that are directly related to the external environment) we can distinguish at least three sub-processes: production (transforming given inputs into given outputs), environment scanning (operational and/or strategic), and internal control or management (see Fig. 2). In this paper we extrapolate that such three sub-processes are applicable to any process in an enterprise, because also enabling processes and other management processes have to scan their environment inside the enterprise.

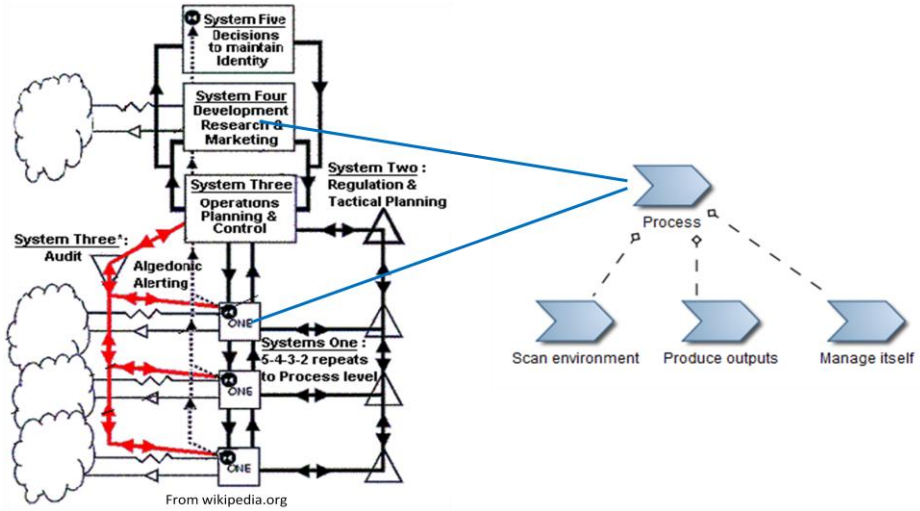

Fig. 2. Viable systems model: a process perspective

Application of viable systems model for contemporary enterprises is a multidisciplinary research topic, which is out of the scope of this paper. Hereby we just borrow the idea of necessity to be aware of external environment, to produce the value, and to be able to manage itself (quality management, change management, etc) for each autonomous unit (we regard the process as an autonomous unit here). Another issue is that while the viable systems model has a fractal architecture, the fractal architecture of information systems proposed in this paper is viewed from the point of view of an information system as a subsystem of an organization, not just from the point of view of operational fractals of the viable systems model.

3 Similarities in Information Systems Support for Organizational Processes.

As described in previous section, the viable systems model indirectly prescribes that each value producing unit has to be aware of its environment, and handle the value production and self-management sub-processes. Each of this sub-process certainly needs information that, in turn, is supported by the information systems sub-processes (see View A in Fig. 3). These information systems sub-processes have to be supported by particular human or artificial information handling units that represent a specific part of information systems architecture. Thus there will be and information systems process behind of each business process as it sub-process (View B in Fig. 3). This information systems process includes information system sub-processes for environment scanning, value production, and self-management.

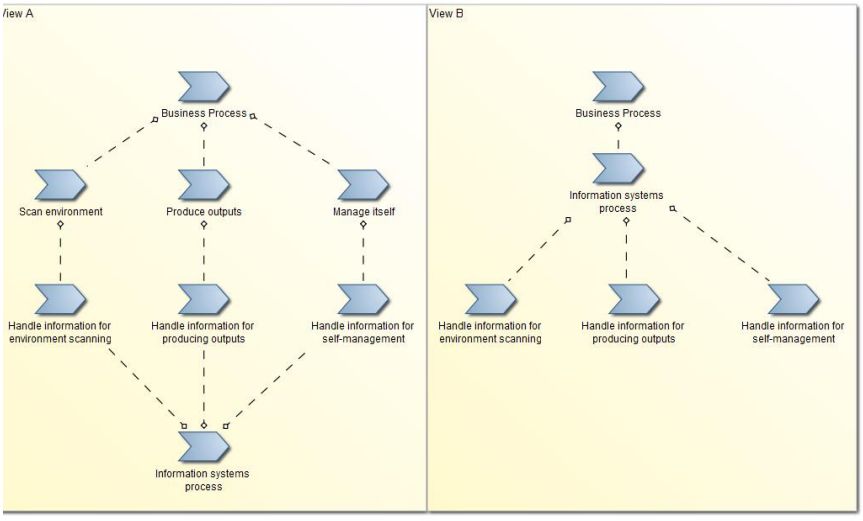

Fig. 3. Information systems process as a sub-process of business process (View A - sub-process level dependency, View B - process level dependency)

The information systems processes are part of work systems that are handling them. Thus behind each information systems process, that supports business process, there is a work system capable of information handling for the particular process (see Fig. 4). The work system in Fig. 4 is a part of work system reflected in Fig 1.

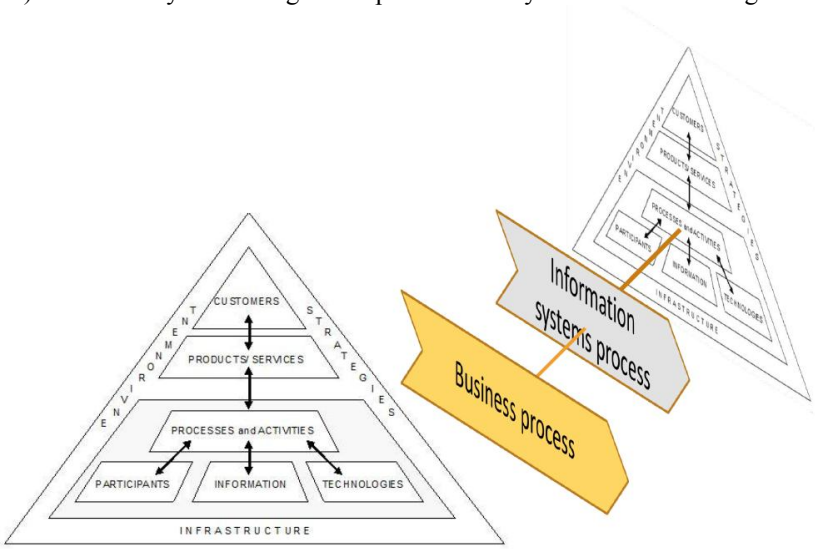

Fig. 4. Information systems architecture work system behind the business process (via corresponding information systems process)

From the process point of view all work systems behind information system processes are self-similar, they have to have a measure autonomy, and they are a part of a whole work system that supports all information processes in a an enterprise. Thus work systems that support business processes form a fractal architecture [7], [9] that can expose a high level of flexibility needed for agile and viable companies.

On another hand, information systems management also is a business process, thus the scanning of information systems environment, information production, and management of information system are sub-processes to be supported (recursively) by the information system. This applies to information systems processes at a high level of abstraction as well to physical processes, such as cloud management or software development process management, or hardware cluster management [1], [2]. In all cases the same type of work system processes are present, just at different level of scale and using information systems architecture elements of different substance (see Fig. 2, Fig. 3, and Fig. 4).

The proposed fractal elements of the information systems architecture can be recognized at two dimensions: from the value production dimension and the work systems substance dimension. At the value production dimension we consider all business process including their variants and value production oriented decompositions. Value production oriented decomposition is different from business process sub-process types reflected in Fig. 2 and Fig. 3. Value production

decomposition means product oriented decompositions, e.g., the process "educate students" can be decomposed into sub-processes "educate students in chemistry" and "educate students in physics" (alternatively these can be viewed as process variants, too), the process "manufacture cars" can be decomposed into sub-processes "manufacture sport cars" and "manufacture city cars", or "manufacture engine" and "manufacture navigation system". We use the value production dimension at the business level. At information systems level we use work systems substance dimension, where the work system can be considered as a virtual actor composed from human participants and technologies: software, and hardware elements (Fig. 5) (including different its variants and decompositions still reflecting human actors as part of the work system); software (application software and/or systems software) together with hardware systems; as well as pure hardware systems with embedded information handling functions.

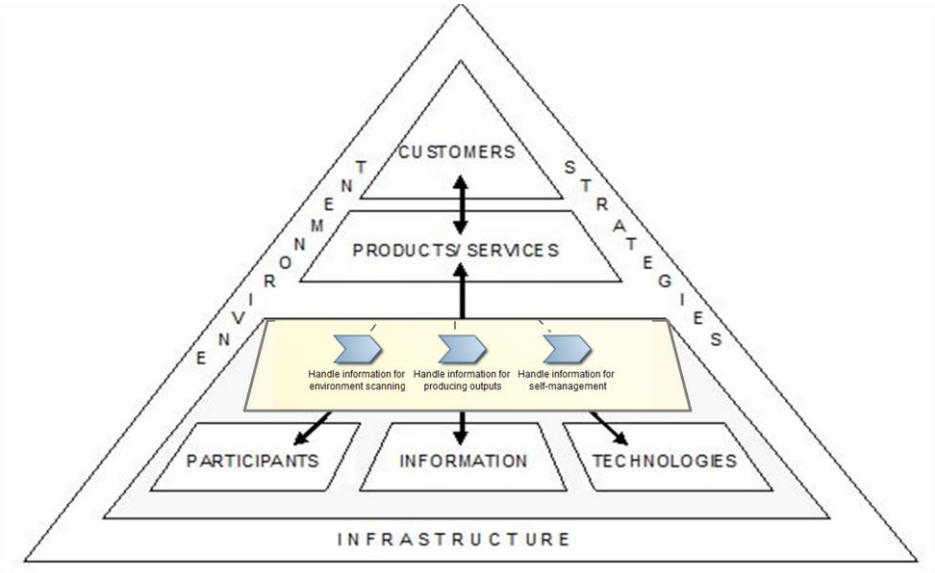

Fig. 5. An element of fractal information systems architecture

The work systems element of information systems architecture, reflected in Fig. 5 suits for both: business value production dimension and work systems substance dimension, from the point of view of information handling.

4 Discussion

There are the following benefits from viewing information systems architecture as a fractal architecture composed of multiple work systems:

- This helps to ensure that all business processes are supported by information system services (sub-processes for environment scanning, value production, and

self-management). These services or sub-processes are essential for agile and viable companies as they have to cope with unpredictable changes in their environments.

- Consideration of information systems architecture as a fractal system of work systems gives an opportunity to at least recognize (and if possible - manage) all actual virtual information system work systems supporting the business system regardless of ownership of software and hardware and regardless of functional boundaries of an enterprise.
- Since the work system can be considered as a virtual system, the changes in the architecture can be introduced on a regular basis by combining the work systems or introducing their new versions at the needed level of abstraction or granularity, based on self-similarity principles of fractal systems [7].
- While the particular concept of work system is introduced on the basis of viable systems model (Fig. 2) by considering its operational and strategic processes that have to directly analyze the external environment of an enterprise, still the concept is applicable also for business processes that do not belong to two abovementioned categories. Such approach enables to look beyond not only functional boundaries of an enterprise, but also to consider customers of the enterprise as partners and switch between physical and virtual boundaries of enterprises in modeling of information systems.

Currently the proposed approach of considering information systems architecture as a fractal system of work systems is applied to two library processes in an university. Library processes do not belong to operational or strategic processes directly. Nevertheless they may have a direct relationship with the external environment. We consider two processes - book ordering and acquisition of electronic resources. The information systems work systems for both processes cross several functional units of the university and for both processes environment scanning, value production, and self-management sub-processes are relevant. Similar information technology support is used for external environment scanning and internal environment scanning (e.g. acquisition of usage statistics and acquisition of popularity statistics). The results obtained so far show that a specific organizational processes and work systems based information systems architecture management system is needed to fully benefit from the application of work systems based fractal information systems architecture.

5 Conclusions

The paper proposes to use the concept of a work system for designating virtual and physical components of fractal information systems architecture. The proposal roots in related work on work systems by St. Alter [5] and contemporary applications of viable systems model [6], [7], [8]. However, here the notion of fractality does not exactly consider (but can incorporate) recursive fractality prescribed by viable system model. In the proposed approach, the fractality is considered from the point of view of the value production dimension and the work systems substance dimension. The value production dimension concerns value for external customers as well as value for

internal customers. The approach allows to consider customers as partners and to switch between physical and virtual boundaries of enterprises in modeling of information systems. The work systems dimension permits to view the basic information system sub-processes at the level of virtual actors composed of human actors, software, and hardware; at the level of software and hardware; and at the level of hardware only.

The work system is suggested to be considered as an architectural component that for each given business process supports environment scanning, value production, and self-management.

The paper is limited to the introduction of the concept at a high level of abstraction. Two experiments are currently in progress to clarify the details and prepare the ground for defining requirements for work systems based fractal information systems architecture management system. A number of case studies in varieties of contexts will be needed to provide detailed guidelines for application of the proposed concept.

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