A Systemic Model for the Description and Comparison of Models and Standards of Processes in SE, SwE and IT disciplines

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Modern business firms can be considered complex system of systems and their engineering and managerial process complexity has been consequently raised. Standards and models of processes –as formalized best practices- have been fostered to treat such a problematic situation, but their inherent complexity has obscured a clear understanding and lately a straight deployment. We argue that the Theory of Systems –posed originally for studying general systems- can provide the conceptual tools for addressing this problematic situation. A systemic model to describe and compare standards and models of processes is

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reported. The aim is to reduce their understanding complexity. The problem is not dissolved but the initial findings suggest an improvement in the treatment of such a problem.

1 Introduction

In nowadays, the competitive-market pressures on the international business firms have affected the design and manufacturing of innovative technical, cost-efficient and trustworthy products as well as the reliable provision of high-quality services. Such engineering and management organizational processes into enterprises can be considered as a complex system of systems (SoS) [Carlock and Fenton 2001]. A SoS is comprised of a large variety of self-purposeful internal and external system components, system interrelationships and unexpected emergent behaviors in multiple scales. A relevant consequence of such a realization is the raising of an engineering and managerial understanding complexity. Observable negative effects are: (i) critical failures of enterprises information systems implementations, (ii) the apparition (and necessary retirement in the market) of defective products (as tires, medicines, cars, software) and (iii) the increasing of system downtimes and/or low efficiency and effectiveness in critical services such: electricity, nuclear plants, health services and governmental services [Bar-Yam 2003]. Under this new managerial and engineering context, the organizations with global and large-scale operations have fostered the development and formalization of best organizational practices through standards and models of processes [Arnold and Lawson 2004]. The purpose is to improve the definition, coordination and execution of internal and external business processes and to avoid critical failures in the manufacturing of products and the provision of services.

However, because of (i) the myriad of models and standards reported in SE, SwE and IT disciplines, (ii) the increasing interaction between SE and SwE disciplines (with the consequent convergence suggested for SE and SwE models and standards), and (iii) the critical role dependence played by the emergent CITO (complex IT-based organizational systems) [Mora et al 2008] in worldwide organizations, we argue that a correct deployment of such standards and models of processes has been obscured by an inherent understanding complexity manifested by a high-density of concepts and interrelationships described in the models and standards [Roedler 1996] and by a lack of an integrated SE, SwE and IS view [Mora et al 2007]. Then, in this article we develop a model to describe and compare standards and models of processes with the goal to reduce such an understanding complexity. Our model is designed by using the foundations of the Theory of Systems [Ackoff 1971; Gelman and Garcia 1989] through a conceptual design research approach [Hevner et al 2004]. Systemic model’s usefulness to capture, organize and present the complex dense information is illustrated with the description and comparison of the CMMI v.1.1 model [SEI 2001] and the ISO/IEC 15288:2002 standard [ISO 2002].

2 The Systemic Rationale of the Standards and Models of Processes in SE, SwE and IS Disciplines

2.1 SE, SwE and IS disciplines

Mora et al [2008] compare the general definitions for these disciplines by using the systemic PQR concept [Checkland 2000] which defines the core function (P: what does the system generate?), the architecture (Q: how is the system structured to execute its core function?) and the purpose (R: why does the system do such a core function?) of any system. At first glance, the three disciplines study very different kind of systems: a well-defined physical system, a computer-based software system and an IT-based organizational system. However, recent SE [Rhodes 2002], SwE [Boehm 2000] and IS [Mora et al 2008] literature has noted the increasing inclusion of software and IT components in the emergent complex organizational systems. For instance, Rhodes [2002] remarks that the software is a critical component, like hardware and people, in the entire artificial organizational system developed by systems engineers. In SwE discipline it has been also suggested that software systems must be considered as socio-technical software-intensive systems [Sommerville 1998]. From an IS perspective, such a definition corresponds to that is considered an Information System [Mora et al 2003] and that has been extended as a complex IT-based organizational system (*e.g.* the CITOS concept) [Mora et al 2008]. Therefore, the interaction between IS, SwE and SE disciplines - derived of the common CITOS concept- under different systemic scales is highly required.

2.2 The Concepts of Standard and Model

To cope with such raising engineering and managerial complexities, the organizations have fostered the utilization (deployment and exchange) of best organizational practices. These have been formalized via models and standards of processes. Their main similarities can be identified from several sources [Sheard and Lake 1998; Mora et al 2007] as follows: (i) both provide a map of generic processes from the best international practices, (ii) both establish what-alike and must-be instructions rather than how-alike specific procedures, and (iii) both suggest a lifecycle process even though is not reported as the mandatory to be used. Then, the implementers must complement such recommendations with detailed procedures and profiles of the required deliverables. In turn, their main differences can be accounted as follows: (i) the models (at least the early reported) have been focused on process improvement efforts (and consequently include a capability maturity level assessment such CMMI) while that the standards are focused on an overall complain/not complain general assessment (e.g. ISO 12207), (ii) the models are used under an agreement between companies to legitimate their industrial acceptance (e.g. CMMI in the Americas) while that the standards are used under a usually obligatory implicit country-based agreement (e.g. ISO 15504 in Europe), and (iii) the models can be originated from any organization while that the standards are strongly endorsed by nations.

2.3 The Systemic Rationale of the Standards and Models of Processes in SE, SwE and IS

According to the ISO 9000:2000 series of standards [ISO 2007], there are eight management principles that sustain its rationale. Two of them (Principle 4 and 5) endorse respectively the process approach and the systems approach as critical management paradigms. The fourth principle establishes that an organization will be more likely to achieve the results expected efficiently, if organizational resources and activities are managed as ***processes***. In turn, the fifth principle sets forth that an organization can identify, understand and manage more efficiently and effectively the ***processes*** if they conceptualized them as a ***system***. Furthermore, the ISO 9000:2000 standard remarks that "… *concerns the way an organization goes about its work … concern processes not products – at least not directly*" [ISO, 2006]. However, this standard admits also that "… *the way in which the organization manage its processes is obviously to affect its final (quality of) product*" [*ibid*.].

Then, the concepts of ***process***, ***system, product*** and ***service,*** attributes and heir conceptual interrelationships become critical for understanding the different standards and models under study. From an analysis of the relationships between ***process***, ***product***, ***service*** and ***system*** in the context of standards and models of process [Mora et al 2007] can be identified multiples views of the concept of ***process***. However, main shared attributes are: (i) an overall purpose (transform inputs in outputs), (ii) activities interrelated, and (iii) the utilization of human and material resources, procedures and methods. The concept of ***service*** is used implicitly for standards and models except by those focused on such an issue. Because the most important standards and models of processes for IS are being oriented toward services (ITIL, CobIT, ISO 20000) and the SwE/SE disciplines are starting to be focused also toward such a purpose (for instance: CMMI-SVC), a plausible generic definition of what is a ***service*** is fundamental. There is not a unique definition for the concept ***service*** but several shared attributes can be identified: (i) intangibility, (ii) non-storable, (iii) ongoing realization, and (iv) a mandatory participation of people to determine its value attribute. While automated processes (by using artificial devices) can assess the quality attributes of products (e.g. to fit some agreed physical specifications), we argue that only the human beings can assess a value scale on ***services*** (even though such services can usually include machine-based metrics). Main visible distinctions between the ***product*** and ***service*** concepts are: (i) the tangibility-intangibility dichotomy that leads to the quality (e.g. the attributes expected in the product) versus the value (e.g. the benefits to the quality-prices rate perceived from customers' perspective), and (ii) the ongoing service experience [Teboul 2007] versus the time-discrete utilization of products. An additional conceptual difficulty to define such concepts as potential building-blocks to describe and compare standards and models of processes is the omission of the responsible entity that generates a ***service***. We argue that the concept of ***system*** [Gelman and Garcia 1989] becomes a critical concept to link logically the ***process*** and ***service/product*** constructs. Similar conceptualizations are being developed also in the SSME's research stream under the notion of service systems [Spohrer et al 2007].

3 The Systemic Descriptive and Comparative Model of Standards and Models of Processes

The model is described by two sets of conceptual relationships based in the Theory of Systems [Ackoff 1971; Gelman and Garcia 1989] and a classic organizational cybernetic paradigm [Gelman and Negroe 1982] extended to include the informational-organizational subsystem concept [Mora et al 2003], through a conceptual design research approach [Hevner et al 2004]. Model was designed by two lead authors and validated by remainders three co-authors. Overall assessment is positive. The first set defines the concepts of: ***system***, ***subsystem***, ***component*** and ***suprasystem-entourage***. The second set defines the concepts of: ***organization***, ***organizational subsystem***, ***business process***, ***business sub-process***, ***business activity***, ***product*** and ***service***. By space limitations, the definitions are reported in the Appendix A and B.

To apply the conceptual definitions and relationships, we define a set of pro formas [Andoh-Baidoo et al 2004] for each concept (see appendix C). Pro formas and the systemic definitions enable us to develop a multi-scale systemic comparison of standards and models of processes. This strategy is better than a direct comparison between them because there is a common normative pattern against to each standard can be compared. However, it is required at first, to describe each standard by using such pro formas before to perform the comparisons. As an illustration, in this paper we report the description and comparison of the ISO/IEC 15288:2002 standard and the CMMI/SE model in the appendix D. The description and comparison is conducted in the organization and the organizational subsystem levels (driver, driven and informational). Such descriptions map the set of processes of both schemes onto the generic-normative systemic model of an organization. Through the generation of the systemic pro formas and their interpretation, we identify the following core insights:

1. Both schemes (the ISO/IEC 15288 standard and the CMMI/SE model) are focused in the core processes related to the man-made system lifecycle and related support process. However, from a classic process-based organization model [Porter and Millar 1985], top management and information systems support process are not fully addressed. ISO/IEC 15288 standard addresses partially such processes through the Enterprise Processes of <Investment Management>, <Resource Management> and <Enterprise Environment Management>, as well as with the Project Processes of <Information Management>. The CMMI/SE model does not report similar processes. Most related top management processes are into the Process Management area with the specific processes of <Organizational Process Focus>, <Organizational Process Performance> and <Organizational Innovation and Deployment>. None explicit reference to IS processes is reported in both schemes.

2. While both schemes are rooted on the ISO 9000:2000 series of standards, and consequently the quality issue is fundamental, the ISO/IEC 15288 standard assigns an overall enterprise scope to the <Quality Management> process (e.g. this is defined in the Enterprise area) while that the CMMI/SE model locates this process as a support process (e.g. the <Process and Product Quality Assurance> process). We consider that this minor location of that can lately affect the scope of the quality management initiative for the full organization.

3. Both schemes promote the maturation of the performed processes. However, their strategies to define and improve are slightly different. The CMMI/SE model

provides a more robust strategy by including the <Organizational Process Focus>, the <Organizational Process Definition>, the <Organizational Innovation and Deployment> and other processes in the Support category to lately define, monitor and improve all processes used to generate products and services. In the case of the ISO/IEC 15288 standard, the unique related process is the <System Lifecycle Management> process. However, despite this is located in the Enterprise area (and consequently has a broader organizational scope than the processes from other categories), its focus is on Technical process.

4. Regarding to the Support and Agreement Processes, their strategic scopes differ. For the CMMI/SE model, the support processes are focused in the monitoring and improvement of the technical processes (through quantitative, decision-making and causal analysis). In the case of the ISO/IEC 15288 standard, some of these core support processes are located in the Project category. Furthermore, the Support category of processes is replaced by the Agreement category. Into this category, the role of the organization as both buyer and supplier of goods and services is considered. For the case of the CMMI/SE model, the agreements are focused in just one side of the value chain: as acquirers.

5. With respect to the Project category, besides of the differences aforementioned by the Agreement versus Support categories used in the compared schemes, both ones provide the same core of process: <Project Planning>, <Project Control>/<Project Monitoring and Control> and <Risk Management>. In the ISO/IEC 15288 standard, the <Configuration Management> process is located in the Project category, while that in the CMMI/SE model is classified as a Support process.

6. With reference to the Technical processes, the differences are minimal from a SwE perspective: there are processes for <Requirements Management>, <Requirements Development> and <Technical Solution> design and building. However, while the CMMI/SE claims to be a model for systems engineering, this model does not report explicitly the usual considered phases (and processes) in SE: <Operation Process>, <Maintenance Process> and the <Disposal Process>. Then, the ISO/IEC 15288 standard (being a SE standard) covers such SE issues more adequately than the CMMI/SE model.

4 Conclusions

We have argued that, in nowadays, the modern business firms can be conceptualized as complex systems of systems (SoS) regarding to the engineering and managerial processes to deliver cost-effective, trustworthy and high-quality products and services. Consequently, the organizations have developed and promoted the exchange of “best practices” through standards and models of processes. However, the myriad of them is causing an understanding complexity that obfuscates their correct deployment. In this paper, we have posed the utilization of the Theory of Systems for treating such an understanding problematic situation. Our plausible realization was illustrated with the definition of a systemic model of organization, organizational subsystem and business process, and the model was applied to describe and compare two schemes: the ISO/IEC 15288 standard and the CMMI/SE model. We cannot claim that this model is sufficient to fully dissolve the problem addressed. However, we claim that the systemic model alleviates it by helping to academicians and practitioners to acquire a better view of the models and standards of processes through a mapping of the organizational processes provided by them onto those into a generic-normative organization. We will continue this research with: (i) the addition of more standards and models, (ii) a next level of detail in descriptions and comparisons, and in the middle term with (iii) the semi-automation of such an analysis through ontologies-based and reasoning computer-based tools.

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