Modeling Organizations: The *“Operating Systems”* metaphor

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Abstract. In this paper we propose and discuss an organizational model to describe the execution of business activities. This model offers a dynamic, actor-centered, context-based and business process oriented perspective of the organization. The model explicitly addresses information and collaboration needs derived from human multi-tasking capabilities and aims to facilitate the design of systems for a personalized, proactive and timely support of human business actors. We illustrate the model ideas with some simple examples.

1. Introduction

The highly dynamic nature of today’s organizations continually presses for faster ways of obtaining the information required for their operation. Despite the number of tools and systems developed to collect, organize and disseminate the information created throughout the organization, people continue to spend time searching the information needed for their work. This situation is aggravated in knowledge intensive tasks, which have greater information and collaboration requirements. When performing business activities, knowledge consumers should receive information according to their specific needs. Further, knowledge production activities should minimize the disturbance of workers’ core activities. In order to meet these requirements, personalized, proactive and timely mechanisms should be devised.

Current knowledge management systems offer limited solutions to the problem of knowledge provision and are frequently deserted by users [2]. Recent research projects [4,12] are recognizing the subjective, social, and contextual nature of knowledge, and are promoting a distributed, context-based approach to knowledge management. Theoretical frameworks and technical solutions are being developed aiming to provide a more appropriate support of knowledge-related processes. A context-based approach of organizations is also proposed in [19]. This work makes a case for the need of making explicit several kinds of organizational contexts.

However, these developments are not business process-oriented and do not focus the dynamics of individuals’ behavior changing at work. Both people and business processes are business actors capable of performing several tasks and roles. Therefore, business actors exhibit different behaviors with different information needs. These needs depend on a number of factors such as individual features, task at hand and role played. A timely and proactive information provision entails considering not only actor, role and task-related features. It must also take into account the dynamics that governs task changing behavior. Capturing these dynamics requires (1) a different business modeling approach, (2) defining new business concepts and (3) adapt existing concepts ones to the newly defined concepts.

Our work pertains to the business modeling area. Business models allow organizations to communicate, document and understand its activity [5]. In order to manage the organization complexity, business models use a number of different perspectives. A business process perspective of organizations implies relating a set of activities in sequences that deliver some value to internal or external customers. Modeling business processes involves capturing interactions between multiple business objects, such as activities, goals, resources and human or automated actors [6]. Workflow management systems are a supporting technology for business process modeling, optimization and automation [7]. Since the semantics of business process models and workflows are similar, workflow schemas can be directly derived from business process models [8]. As workflows enable information dissemination among users and systems, they also facilitate a "process oriented" knowledge management [9]. Nevertheless, a process-oriented knowledge support through workflows has two limitations. First, conventional business process models and workflows support planned and predefined work, offering little flexibility. Although adaptive, agent-bsed and event-driven workflow flexibility [25,26,27] an appropriate support to human actors of ad-hoc and ill defined processes has not been achieved. Second, conventional business process models and workflows do not capture business actors' changing behavior patterns. They describe actors as uniform units with a single behavior. This forces the representation of actors' different behaviors as independent and unrelated units. Role based modeling [5,6] overcomes this limitation by enabling the representation of different "views" of a single actor. This approach addresses static aspects of actors' multiple behaviors. In order to give business actors an overall, proactive and timely knowledge support, it is necessary to address the dynamic aspects of behavior changing. This entails capturing actors' engagement and disengagement patterns to tasks and roles.

In this report we refine and discuss the benefits an organizational model to describe the execution of business activities introduced in [16]. This model offers a dynamic, actor-centered, context-based and business process oriented perspective of the organization. The model explicitly addresses information and collaboration needs derived from human multi-tasking capabilities. This modeling approach aims at providing a richer, efficient and flexible model for better representing the complexity of business actors and their interactions, to (1) facilitate the design of systems for an overall, proactive and timely information and collaboration support to business actors and (2) provide a bottom up approach for the specification of organizational tasks, roles and interaction protocols.

The remaining of this report is structured as follows: section 2 reviews related work on context and role-based modeling, section 3 defines the core concepts of our work, section 4 presents the proposed modeling approach. Section 5 illustrates some of these ideas. In section 6, we give our conclusions and future directions.

2. Related work

This section presents related work supporting our concepts and modeling approach. Section 2.1 summarizes the notion and uses of context developed by context-related research. Section 2.2 describes role-based business process modeling approach.

2.1. The notion and uses of context

Although the notion of action context plays an important role in multiple disciplines such as pragmatics, natural language semantics, linguistics, cognitive psychology, and artificial intelligence [10], there is no standard concept or theory. The notion of context varies according its area of application. However, there is consensus around the relational nature of context i.e. context is not an autonomous entity, is always related to something else. This section describes engineering and sociological approaches to context.

Classical engineering approach: From an engineering perspective, context is viewed as a collection of things (sentences, propositions, assumptions, properties, procedures, rules, facts, concepts, constraints, sentences, etc) associated to some specific situation (environment, domain, task, agents, interactions, conversations, etc). This consensus is reflected by the "box metaphor" [11]. The intuition is that context can then be seen as a container where its content depends on some set of situational characteristics or parameters (figure 1).

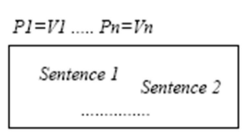


Fig. 1. The *"Box Metaphor"*

The specific set of parameters varies according to the areas of application. In pragmatics, indexical expressions are defined as expressions dependent on indexes such as place, time, agent and world, which are a subset of context parameters. In Artificial Intelligence, parameters (called dimensions) such as time, location, culture, topic, granularity and modality among others, have been proposed as defining elements of context space [13]. A proposal for a workflow context space in [14] includes the following parameters: function, behavior, causality, organization, information, operation and history. In the area of context aware applications localization, user identity, activity and time have been identified parameters of context [15]**.** In terms of its use, context is employed mainly in two broad different ways. On one hand, context has been used as a partitioning or grouping means. This kind of context use has two different purposes: (1) enable filtering, classification or customization mechanisms and (2) achieve an efficient representation or reasoning. On the other hand, it has been employed as a means for making explicit assumptions, interpretations or concepts, to resolve interoperability problems derived from heterogeneous information or data interchange.

Sociological Approaches: Seeking to improve system sensitivity to specific settings, research in context-aware computing is focusing on a view of context inspired by sociological investigations of real-world practice [30]. This work contrasts the objective account of engineering and the subjective account of phenomenology and discusses the implications of approaching context from the latter perspective. The phenomenological perspective argues that (1) context is a relational property among objects, (2) the scope of contextual features are defined dynamically, (2) context is relevant to *particular* settings, instances of action and participants and (4) context and activity are not separable i.e. context is embedded in activity and arises from it. Under this perspective, the focus moves from context representation to context support.

The apparent contradiction between the objective and subjective positions is denied by Structuration Theory [31], which seeks a balance between both positions. According to this theory, through interactions actors both produce and reproduce social practices. On one side, social practices are produced from interactions among subjects. On the other side, from these interactions emerges an objective structure (context) which provides rules and resources that simultaneously support the reproduction of social practices and constrain subject interactions.

2.2. Role based Business process modeling

Conventional business process models describe actors and other business objects with a pre-defined and uniform behavior. This leads to the representation of business objects capable of exhibiting multiple behaviors as independent and unrelated units. Role based Business process modeling [5,6] overcomes this limitation by enabling the partition of business objects behavior according to its relationships with other business objects. Business objects interact and relate with other business objects and play roles for each other during these collaborations. The overall motivation for role-based business process modeling is allowing several views on a single business object. These views are used by other business objects to selective access the object. A view is a set of selected properties. An important feature of these views is that they can change dynamically, i.e. be added or removed from a business object. Figure 2 illustrates how role-based business process modeling enables several views of business objects.

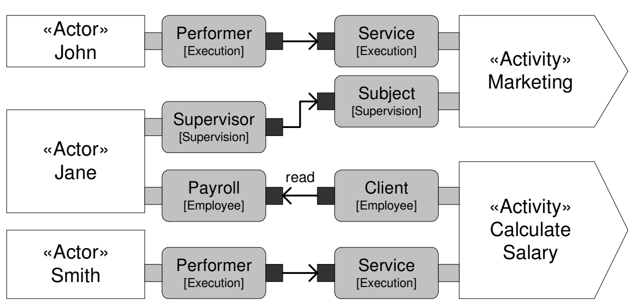


Fig. 2. Role-based modeling example [6]

Each one of these views is modeled as a role. A *role* defines the properties of the business object that are relevant when interacting with other business objects, thus defining a part of its observable behavior. The union of all roles that a business object can play defines its complete observable behavior. This example shows how a business object may behave differently depending on its usage context. The business object

Jane, which is modeled as an actor and plays a supervisor role in its collaboration with the marketing activity, is related to the calculate salary activity via the employee role. This role defines the specific business properties that are required for an actor to have so that its corresponding salary may be computed.

3. Action and interaction contexts

This section presents the core concepts of our approach. The concepts of action and interaction contexts enable addressing the multi-tasking nature of business actors. Actors and their interactions are approached establishing analogies with multi-tasking operating systems and distributed systems.

3.1. Actors' multi-tasking behavior

Human beings by nature are capable of alternating among several, independent tasks. When engaged in several activities, people "break" these activities and "jump" among them according to criteria such as task priorities, task resource's availability or scheduling-related habits (ex. hour preferences, dispatching shorter tasks first, etc.). Human multi-tasking capabilities and its limitations are studied in Experimental Psychology [18]. Several theories from this area claim the existence of mental executive control processes that supervise the selection, initiation, execution, and termination of tasks. An analogy of these executive processes with computational multi-tasking operating systems has been established in [19]. Understanding executive mental control, which defines human actors' basic operative behavior, may help to understand and describe the dynamics of human actors' behavior changing. Although business actors exhibit distinct behaviors with different information requirements, they are unique entities. Hence, an overall actors' support entails capturing not only its specific behaviors, but also his basic operative behavior.

3.2. The *action context*

The context of a knowledge worker's information needs is determined by three main factors: (1) the individual person, (2) his/her position in the organizational structure, (3) the task at hand [3]. Taking into account all three dimensions promises better results than focusing on any subset. From our point view, information needs are determined by smaller units of behaviors determined by ***action contexts***. Each specific business actor, role and task combination determines a different action context. Action contexts define relevant information and behavior for an individual, role and task *during* the specific time intervals at which the individual-task-role is "active". In terms of the box metaphor, action contexts parameters are individual, role, task and time related features and its contents are the collection of relevant information and behavior items corresponding to a specific set of parameter values. Actors' behaviors and requirements are typically defined according to task or role-related features. By combining task, role and individual's-related-features –such as personal habits and preferences -, we enhance customization possibilities to actor' representation. Figure 3 illustrates the defining features of action contexts.

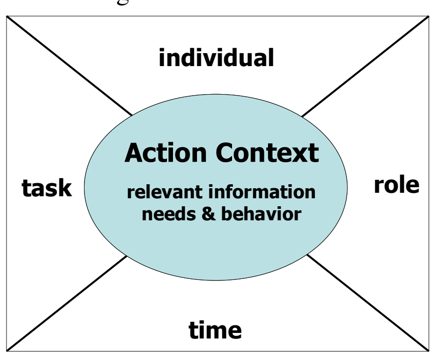


Figure 3. The action context *parameters*

3.3. The interaction context

Business actors interact from specific action contexts and generate a shared space which grows through successive interactions among them. By accepting the multi-tasking capabilities of business actors, their interactions can be approached establishing analogies with distributed systems. All interactions entail a communication process. Distributed systems (human or automated) communication can be modeled as the information transfer from a sender to a receiver. This information transfer is supported by a *channel*. According to Communication Theory [21], this channel entails the use of a sign system. Human sign systems (such as natural languages) are described by a layered model with four interdependent levels; *empirics, syntactics, semantics and pragmatics*. In the case of automated actors, the ISO/OSI model provides the standard communication channel for distributed computational systems, including Unix sockets, application integration's middleware, agent[32] and web service communication models [23]. The ISO/OSI model addresses empirical and syntactical layers. Advances in Ontology research, are providing higher level syntactics and semantics to communication among automated actors such as agents and web-services [22,24]. The inclusion of interaction protocols and roles has brought pragmatic-related elements to agents' communication [1].

In our work, we focus the *"communication channel"* of business activities. Each business activity in execution originates a communication channel defined as the **interaction context**. Interaction contexts provide the *shared empiric, syntactic, semantic and pragmatic channel* for action context communication. Interaction context behavior is determined by role structures, assumptions and expectations, rules and protocols. Interaction context reflect actual activity-related states of affairs and behavior. Based on our role definition, "observable" behavior of action contexts are part of the interaction context. Thus, these two concepts are somewhat overlapped. The inclusion of action and interaction contexts as overlapping but different concepts, seeks to consider both the subjective nature of knowledge (action contexts) and its social nature (interaction contexts). On one side, interaction contexts represent, knowledge derived from the interactions among action contexts. On the other side, action contexts represent unique behavior and information requirements of individuals.

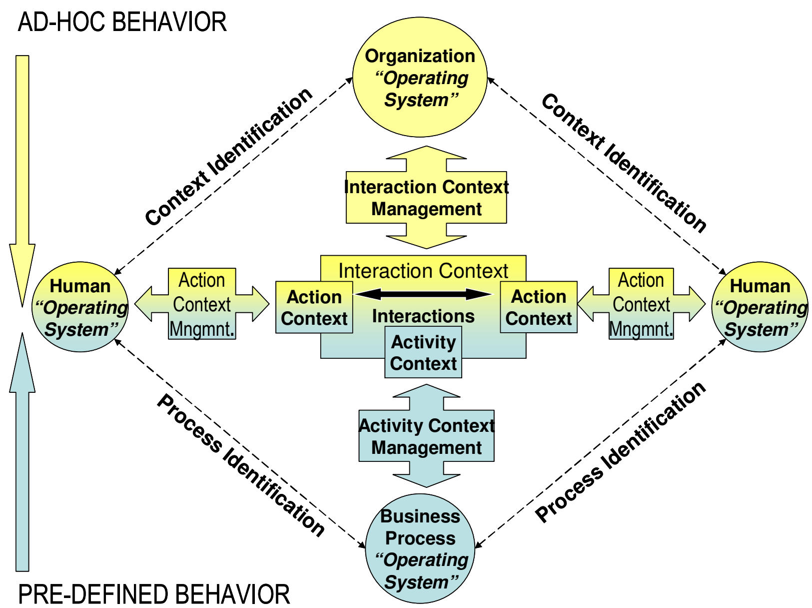
3.4. Approaching business actors as networks

Human beings are designed to identify and use context automatically as we go about our daily lives [17]. Due to their multi-tasking behavior, actors' are able to handle several action contexts. But scarce resources such as attention and short-term memory [20], forces the activation of only one action context at a time. At some specific time frame, actors' information requirements depend on the *active* action context. Thus, when modeling actors, not only several action contexts for each actor should be considered but also, the possibility of switching among them. Modeling actor multi-tasking behavior entails "exploding" the notion of actor. Rather than considering an actor as a single object, we are proposing modeling actors as a network of objects: the action contexts. Action contexts are not autonomous, as they are managed by a different and special object: the actors' operating system. Actor operating system handles actor general synchronization and scheduling capabilities such as action context initiation, termination and switching mechanisms. One core goal of our work is to identify the necessary concepts to capture and model both actor specific behaviors and the dynamics of actor changing behavior. The operating systems metaphor provides a conceptual framework –not related to any current implementation paradigm- that offers a clear cut separation of actual execution aspects from execution management aspects such as scheduling and action context management. This approach enriches the actor semantics of current business process models.

4. The proposed model: an *"Operating Systems"* Metaphor

Due to their multi-tasking capabilities, human business actors are capable of handling several *action contexts* and participating in several *business contexts* .We propose a model to describe the execution of *business activities* that explicitly address human multi-tasking context identification and management operations. Figure 1 illustrates our model. The organization is viewed as a network of individual and collective actors**.** The model explodes the notion of actor and approaches it as a network of contexts managed by actor's own "operating system". Three kinds of actors are defined: *human, business process* and *business context* actor. *Human actors* are modeled as a network of *action contexts*. Human "operating system" determines individual schedules and action context changing patterns. The *business process actor* is a collective actor modeled as a network of *activity contexts*. Its "operating system" acts as an "engine" managing the execution of pre-defined flows of work. *The organization actor* is another collective actor which represents sets of interacting individuals organized for specific purposes such as team or department. It is modeled as a network of *interaction contexts*. The organization "operating system": (1) provides a communication environment reflecting shared assumptions, expectations, habits, rules and interaction protocols, which support and regulate activity-related actions and interactions and (2) manages ad-hoc behavior and exceptions not handled by business processes.

Figure 1. The proposed model based on the Operating Systems Metaphor



The inclusion of two kinds of collective actors explicitly acknowledges the organization's capability to act flexibly by combining pre-defined and structured behavior with new and ad-hoc behavior. It also acknowledges that *operational procedures* handled by business processes and defined independently from specific individuals or groups, are ultimately modified by individual features and *social practices* of the human actors involved in its execution. The importance of considering formal procedures and social practices has been discussed in [28].

The operating systems metaphor is a conceptual framework which provides a dynamic view of organizations with a clear cut separation between actual execution and its management. In order to act or interact, upon the reception of messages, multi-tasking actors must first identify and activate the corresponding action context. This metaphor enables to provide specific support for context identification and management operations. From our point of view, this organizational perspective facilitates a more personalized and timely support to human business actors. An overall view of individual and collective actors facilitates the design of services seeking a balance between individual and group needs. The model assumes a flexible and adaptive business process management. However, we do not focus on business process issues. Rather, we address model context-related concepts from a *business process perspective*.

We aim at building *dynamic* business context models from activity-related action and interaction history. Specifically, we seek to capture elements of: (1) interaction contexts, i.e. *shared action contexts* (2) human "operating systems", i.e. individual *habits* and *action context-changing patterns*, and (3) organization "operating system" i.e., supporting and regulating elements of action context interactions, such as *shared assumptions and expectations, rules and interaction protocols.*

5. Modeling Example

In order to illustrate some of the previous ideas, we include a modeling example based on observations made on a real organizational setting. Alice is an assistant to the presidency of a research institute. Figure 5 shows a static role-based model of three different behaviors of Alice, each one determined by Alice's engagement in three activities; (1) in activity *Elaborate Student's List* playing the role *supervisor,*(2) in activity *Assist Professor* playing the role of *performer* and (3) in activity *Elaborate Budget* playing the *Training Role*.

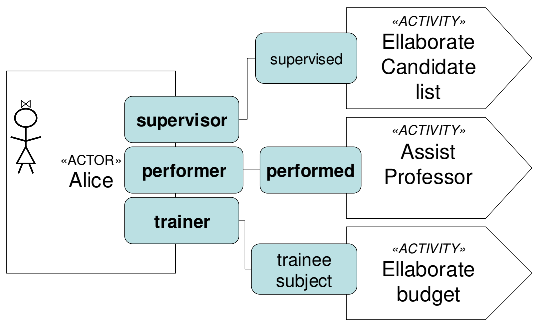


Fig. 3. Alice's roles

Modeling action context changing. Figure 6 illustrates a scenario of Alice's behavior changing. The figure shows a sequence of action context switches and her action context switching rules. While specific requirements and behaviors are represented in action contexts, action context switching rules capture behavior changing patterns. This diagram shows simple scheduling rules, but actual rules are more complex, including more variables degrees of uncertainty. Figure 6a describes one particular scenario. Nevertheless, the goal is to capture lasting patterns of task-switching behavior.

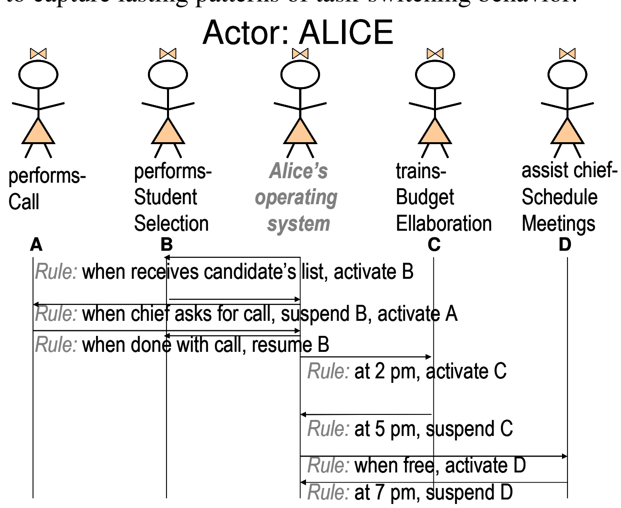


Fig. 6. Modeling action context changing

Modeling interactions among actors. Figure 7-a illustrates a pre-defined interactions among two . When Susan finishes the student list, she sends it to Alice, who's responsible for the student selection activity. Since it is a pre-defined flow, it is handled by the corresponding business process. In our model, it is explicitly modeled (1) the actual student list flow, which goes between Susan's action context and Alice's action context, (2) the specific message which informs Alice that the student list is finished and (3) the action context activation rule that will process the student list (Activate upon reception). Ad-hoc interactions are handled by the business context operating system. Fig. 7-b illustrates and ad-hoc interaction Susan asking for Help. If Susan has an unexpected problem in elaborating the list student, she uses her contextual knowledge and ASK Alice for HELP, as she expects Alice to help her. Alice commits to help her as soon as she is free. Our model captures all these interactions.

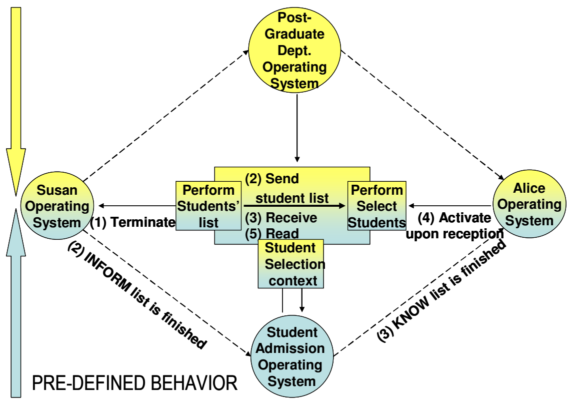


Fig. 7-a Pre-defined interactions

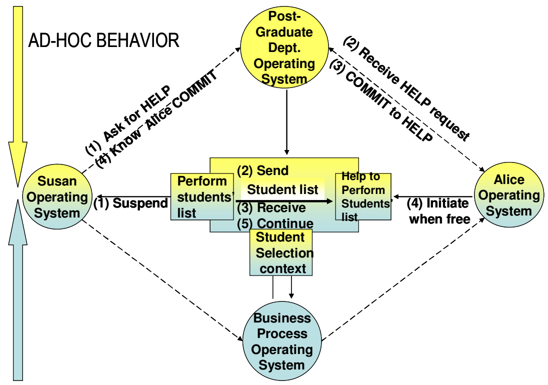


Fig 7-b ad-hoc interactions

6. Conclusions and future work

In this report we refine a *dynamic*, *actor-centered*, *context-based* and *business process oriented* modeling approach to describe the execution of business activities introduced in [16]. *Business contexts* are defined as the interplay of three kinds of context: *activity*, *action* and *interaction contexts*. The model uses an *operating systems* metaphor to address information and collaboration needs derived from human multi-tasking capabilities.

The concepts of **action** and **interaction contexts** are key elements in modeling business actors and the interactions among them. The inclusion of action and interaction contexts in business process models seeks to capture context emergent properties not derivable from other business model elements. Approaching actors as a network of action contexts managed by an "operating system" offers richer and more customizable actor representations. The inclusion of two kinds of collective actors –business process and organization actor explicitly acknowledges the organization's capability to act flexibly by combining pre-defined and structured behavior with new and ad-hoc behavior. It also acknowledges that *operational procedures* handled by business processes and defined independently from specific individuals or groups, are ultimately modified by individual features and *social practices* of the human actors involved in its execution. The operating systems metaphor is a conceptual framework which provides a dynamic view of organizations with a clear cut separation between actual execution and its management. From our point of view, this organizational perspective facilitates a more personalized and timely support to human business actors

The concepts defined and the proposed modeling approach, are preliminary results of our research work. The modeling examples offer simple and limited views that illustrate some ideas of our proposal. An extensive observation and modeling work is still required in order to test, adjust and refine our modeling approach.

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