An Interactional View of Context in Business Processes

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Abstract. Incorporating context in business process descriptions has found increasing interest in the business process management (BPM) community. Most approaches are based on a notion of context as a static representation of relevant aspects of a process. This paper proposes that an understanding of context as a process that generates subjective views of context is more beneficial for business process applications. The paper develops a subject-oriented model for the alignment of the individual contextual views of workers and business process experts, as the basis of a framework for developing methods and tools for interactional context.

Keywords: Context, Business Process Management.

1 Introduction

Business process modelling is concerned with generating abstract representations of planned or existing operations within a business domain. The resulting process models typically include descriptions of tasks, the sequencing of tasks, the resources required, and the data objects created and consumed [1]. They allow performing most activities in the life cycle of business processes, such as design, analysis and optimisation. The abstract nature of process models assists many business process analysts in developing a clear view of the essential properties of a process without being obstructed by specific details. On the other hand, the applicability of process models to specific organisations, users or business situations requires additional information that is often referred to as context. Context can be described generally as "the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood" (*Oxford Dictionaries Online*). In business process management (BPM), the notion of context has been defined and categorised in several ways [2-4]. Most approaches argue that context is the driver for changes in the design and execution of business processes and that the arising need for process flexibility must be addressed by making business processes context-aware [2]. The motivation underpinning the existing body of research is the goal to manage business processes more effectively and efficiently.

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This paper aims to augment the business perspective of context with a people-centred one. It is based on the recognition that a necessary factor for realising any business process, including business process changes, is the human being involved in executing the process. Any model constructed of a particular context, even if it includes detailed characteristics of the process participant, must be consistent with the subjective view of the context that the individual participant interacts with. Questions relating to the ways in which subjective context models can be captured and aligned with objective models of processes (and context) form a research agenda that will be discussed in this paper. Section 2 presents an overview of related work in context-aware business processes and explores the different notions and classifications of context developed to date. Section 3 introduces subject-oriented modelling as a basis for an interactional view of context that is presented in Section 4. Section 4 formulates an initial framework for studying interactional context Section 5 concludes the paper with short discussion.

2 Views of Context

The notion of context has been the object of scientific investigation both in terms of its basic nature and in terms of its application to a multitude of domains. In the last few years the notion of context has slowly become an important source of information in the computing environment [5], for ubiquitous computing [6] as well as for business processes [4, 7, 8]. On the other hand, there is still a lot of controversy based on the heterogeneous nature of context and the context-dependence of the concept itself [9-12], making it almost impossible for the scientific community to agree on a single definition or a unanimously accepted theoretical perspective. Frequently, only few aspects of context are described, modelled or formalized. To get a better understanding of the different views of context for business processes, we conducted a literature review to summarize the accumulated state of knowledge concerning the topic and to highlight important issues that research has left unresolved.

Most research in introducing context into business processes is driven by the need to make business processes more flexible, agile and adaptable [2, 3, 7, 8, 13, 14] and to improve real time handling of process-related issues [14] in the physical world [7]. Specifically, context (and knowledge about the context) is used for achieving a number of goals:

- to identify extrinsic drivers for process flexibility [2, 8],
- to control the flow between activities [7],
- to adapt the execution of the instances to the change and to the stakeholders' requirements . The notion of context covers any circumstances that impacts assignment relations [3],
- to dynamically integrate knowledge and workflow processes by supporting the real-time handling of both the current context of a process and its execution path for knowledge intensive tasks [14],
- to facilitate dealing with contingencies in the business environment and to continuously improve process performance.

With respect to the definition of context, most authors refer to the ones proposed by Dey [5] and Roseman and Recker [2]. Dey [5] introduces a definition for application developers to specify the context for a given application: *"Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves."* Furthermore, he provides a definition of context-aware computing: *"A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task"* (p. 5). Rosemann and Recker [2] apply Dey's view of context to the domain of business processes, defining it as *"the minimum set of variables containing all relevant information that impact the design and execution of a business process"* (p. 154). Saidani & Nurcan [3] provide a further definition of context as *"… the collection of implicit assumptions that is required to activate accurate assignments in the BP model at the process instance level"*.

A summary of existing approaches and methods for identifying, analysing and modelling context in business processes as well as dimensions of context is shown in Table 1. It indicates that most approaches are based on the notion of context as a representational problem [12, 15, 16] that can be characterised using the following statements [12]:

- Context is a form of information that can be encoded and represented.
- Context is delineable, as it can be pre-defined for specific applications.
- Context is stable. The variables that represent the context do not change across different instances of activities or events.
- Context is separable from activity. Information about the context can be captured independently of the action that generated it.

In addition to the understanding of *context-as-representation* (or context as state), Dourish and others [6, 9, 12, 14-16] propose the notion of context as an interactional problem (*context-as-interaction* or context as process) with the following characteristics:

- Context is a relational property that holds between objects or activities. Something may or may not be contextually relevant to a particular activity at a given time.
- Context cannot be delineated and defined in advance. The scope of contextual features is constantly (re-)defined dynamically.
- Context is an occasioned property. It is relevant to particular settings, instances of action and parties involved in that action.
- Context arises from the activity. It is actively produced, maintained and enacted. Context is a process and has a history.

Table 1. Approaches for identifying and analysing context, and dimensions of context in business processes

Authors and approaches	**Dimensions of context**
Rosemann & Recker [2] Context-aware process design approach 1) Context description 2) Design for context 3) Process adaptation	Time; location; legislation; culture; performance requirements
Wieland, et al. [7] *Context data* sensed via RFID tags mounted to tools, Ubisense tags carried by transport carts / workers. *Context event* defined by event description language, registered at context management platform for observation. *Context query* used to get position of worker, spare part, state of machine. Objects of interest are queried at context management platform, injected into internal workflow data. *Context decision* allows process to route process control flow based on context data using context-aware operators.	*Geographical* context (map data); dynamic context (sensor data); *information* context (documents and virtual information); *technical* context (sensors, networks, devices, etc.)
Saidani & Nurcan [3] Context model uses i) Three-dimensional space to describe context related knowledge: S = <ASPECTS, FACETS, ATTRIBUTES> CONTEXT is captured using ASPECTS which are non-functional features; each of them is addressed by some FACETS. FACETS are described by ATTRIBUTES. ATTRIBUTES have features that are directly measurable. ii) Context tree is a three-level tree which root represents global context, nodes at first level refer to ASPECTS, nodes at second level refer to FACETS, leaves at third level refer to ATTRIBUTES.	*Time* (performing time, urgency, frequency, saving of time); location (physical location); *resources* (material & human resource properties, some in relation with work); *organisation* (workplace characteristics)
Heravizadeh & Edmond [14] Context relevance space 1) Identifying issues 2) Identifying context attributes for an issue 3) Defining context attributes 4) Establish conditions over context attributes 5) Reasoning with respect to an issue 6) A set of possible solutions (that is, ways of rectifying the issue).	*Resource-oriented context* (whatever resource are involved); *method-oriented context* (way a task is being executed & time taken to perform task); *environment-oriented context* (conditions applied outside process at the time a task was being carried out)
Rosemann, et al. [8] Procedure for context identification 1) Identify Process goals (hard & soft-goals related to given process & their appropriate measures) 2) Decompose process 3) Determine relevance of context (goal-relevant, extrinsic information on achievement of goal) 4) Identify contextual elements and their interrelations 5) Type context (with the help of the onion model)	Immediate context; internal context, external context; environmental context
Ploesser, et al. [13] Context-aware process management cycle 1) Context mining & learning 2) Context modelling 3) Context taxonomies for industries 4) Context-aware process operations	Variables driving *context-dependent process change* (weather, time, location, resource prices, business partners, strategies, macroeconomic factors); *case context* (properties of customer, asset, purchase order, location)
de la Vara, et al. [4] Context analysis 1) Modelling of initial business process 2) Analysis of business process context 3) Analysis of context variants 4) Modelling of contextualised business process	Context specified as formula of *world predicates*, which can be combined conjunctively & disjunctively; world predicates can be *facts* (verified by a process participant) or *statements* (cannot be verified).

Applying this *context-as-interaction* perspective to business processes would allow making them more adaptive compared to approaches based on static, pre-defined context representations. Such an interaction-based context would directly emerge from the real-time environment in which a process takes place and consider the local interactions and experiences of individual actors within the process. This would enhance the acceptance of business processes among business actors as the processes can be tailored to their individual needs and subjective perceptions of the current process environment. On the long run it would allow contextual business process modelling as a task that can only be achieved when business process experts work together with employees or workers on creating processes and process environments.

Based on the *context-as-interaction* perspective, we define *interactional context* as a process that generates subjective views of a workplace. The workplace is the environment with which a process participant interacts; it can include the techno-physical environment (tools, business objects, physical layout, etc.) and the socio-cultural environment (values, norms, organisational structures, etc.).

Business process "experts" have their own subjective views of what constitutes the context of a particular process, work environment and workplace. However, as they are not personally immersed in business processes and thus do not have first-hand knowledge of the intricacies of daily work routines; their view of a human actor's (i.e.; worker's) context is typically limited. These limitations do not so much concern the major categories or dimensions of context (according to Johns [11] major categories can also be understood as "omnibus context", or representational context); they are more related to the coverage and granularity of contextual parameters within every dimension (with reference to Johns [11] these can be named as "discrete context" or interactional context). The divergence between the process expert's and the worker's views of the business process context is shown conceptually in Fig. 1.

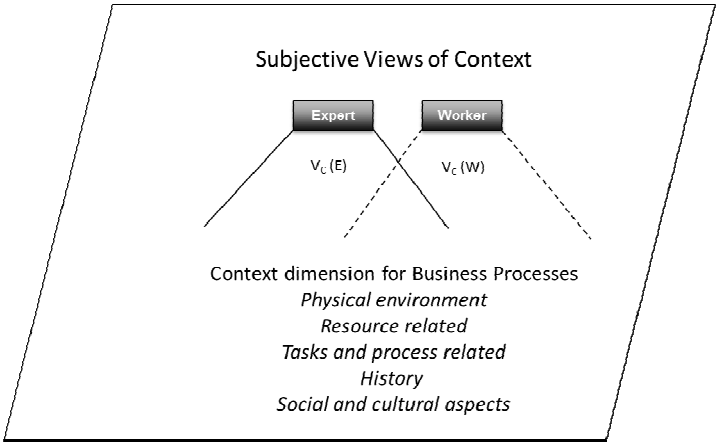

Fig. 1. Different views of context**:** contextual view constructed by the expert (V_C(E)) and contextual view constructed by the worker (V_C(W))

The overlap (or intersection) of the two views in Fig. 1 represents an inter-subjective agreement on the context relevant for both experts and workers, which is the precondition for any representation of context to be applicable in the real world. Inconsistencies of the contextual views with business goals or people-centred goals require their alignment through direct communication between business process experts and workers, and/or through changing the process. This mechanism for contextual view alignment forms the basis of a framework of interactional context that can be represented using subject-oriented modelling.

3 Subject-Oriented Modelling

Subject-oriented business process management (S-BPM) [17] is based on a view of business processes as emerging from the interactions and local behaviours of human actors (i.e. process participants). S-BPM provides a small set of simple building blocks for modelling processes, derived from natural language. The building blocks include subjects (denoting actors), predicates (denoting activities including sending and receiving messages, and performing local tasks), and objects (denoting messages and business objects). The notational simplicity and the natural-language structure of S-BPM afford easy modelling of processes from a first-person view, one that can be easily understood and generated by the process participants themselves.

Figure 2 shows a meta-model consisting of the basic modelling constructs of S-BPM and their connection with actors [18]. A set of subjects compose a business process. They execute actions, captured as predicates, operating on objects. Subjects can execute three different types of actions: Sending messages to other subjects, receiving messages from other subjects and performing local actions on business objects. Business objects can be transported via messages from the sending subject to the receiving subject. Subjects are connected to actors via their roles within an organization or group.

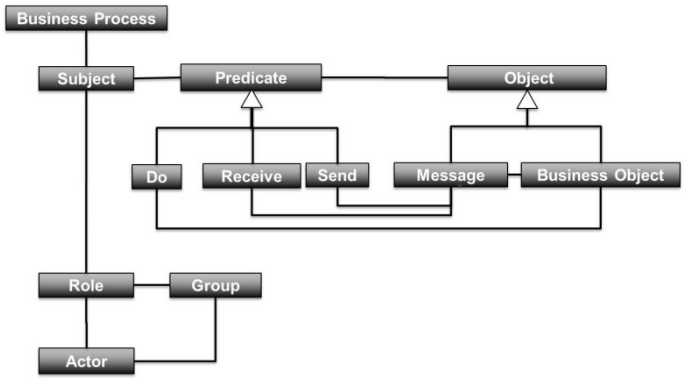

Fig. 2. Meta-model of S-BPM (adapted from Fleischmann, et al. [18])

S-BPM models use two types of diagrams: Subject Interaction Diagrams (SID) specifying the messages exchanged between subjects, and Subject Behaviour Diagrams (SBD) specifying the behaviours of subjects including "receive" and "send" actions operating on messages, and "do" actions operating on business objects. Examples of a SID and a SBD are shown in Fig. 3 and Fig. 4, respectively. Details of the notational elements used can be found in Fleischmann et al. [17].

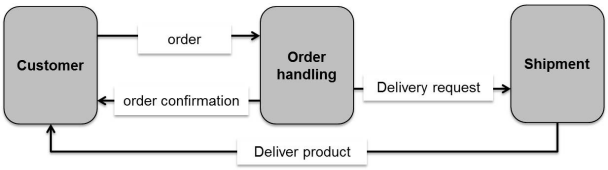

Fig. 3. Subject Interaction Diagram (SID) showing the communication between subjects

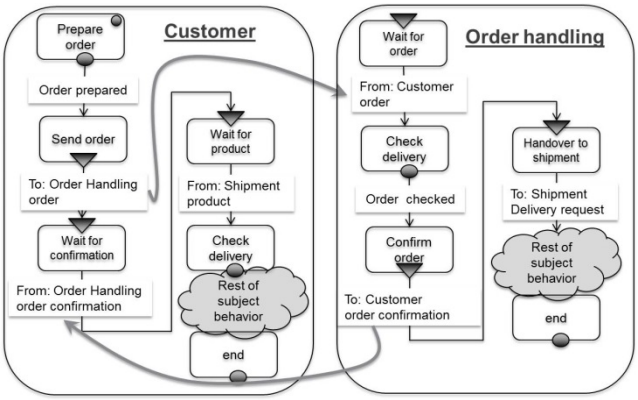

Fig. 4. Subject Behaviour Diagram (SBD) showing the individual behaviours of the "Customer" subject and the "Order handling" subject. Pairs of corresponding "send" and "receive" actions are highlighted using double-headed arrows (not part of the S-BPM notation)

One of the key features of S-BPM is the separation between subjects and roles, as shown in Fig. 2. Roles correspond to organisational positions such as workers, managers, administrative staff, and external consultants. Subjects, in contrast, represent process-specific functionalities that are conceptually independent of the organisational resources deployed to perform them. The separation between subjects and roles allows varying the particular implementation and execution of a process using different roles (and different actors or groups of actors associated with these roles). Take the example of the subject "Order handling": Usually, this subject may be executed by an employee having an "administrative staff" role. Yet, in the case that none of these employees is available (due to holidays, illness or strike), a "worker" or "manager" role may temporarily be assigned to this subject.

4 A Subject-Oriented Model of Interactional Context in Business Processes

Using the S-BPM modelling approach, we can describe the alignment of contextual views with a Subject Interaction Diagram as shown in the SID in Fig. 5. It includes three subjects:

Workplace Designer: develops and introduces formal changes to a workplace to achieve a set of process goals.

Workplace Adopter: uses the designed workplace to perform the work to be done.

Workplace: makes a set of physical and conceptual entities available for interpretation and interaction.

In this process, the subject "Workplace Designer" performs design actions (i.e., actions oriented to designing a workplace) to change the work environment encapsulated in the subject "Workplace". For example, a production manager may rearrange shopfloor operations to include a new production process with a new set of tools, machines, work instructions etc. The current state of this environment is made available to the subjects "Workplace Designer" and "Workplace Adopter". The Workplace Adopter uses this information to construct a subjective view of the workplace, which, in turn, informs further interactions with the workplace by means of use actions (i.e., actions oriented to using a designed workplace). In the production example, the workers construct their individual views and understanding of the changed production process. They interact with the process by executing the process steps, using the tools and machines provided. Feedback regarding the workplace design can be communicated to the Workplace Designer, who, in turn, notifies the Workplace Adopter of workplace design decisions.

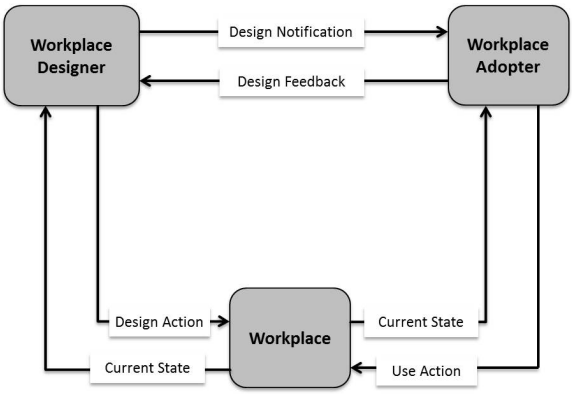

Fig. 5. The process of aligning different views of a workplace represented using a Subject Interaction Diagram (SID)

Different roles may be associated with the subjects in this process. Specifically, two distinct roles are commonly associated with the subjects "Workplace Designer" and "Workplace Adopter":

Expert: is a role that subsumes a set of activities related to specifying business processes. The expert role may be played by managers within an organisation or by external consultants.

Worker: is a role that subsumes a set of activities related to executing business processes. The worker role is played by people directly performing the operations within the business process.

Most organisations use experts as workplace designers and workers as workplace adopters, as illustrated in the production example above. This assignment of roles to subjects is shown as "Scenario 1" on the left-hand side of Fig. 6.

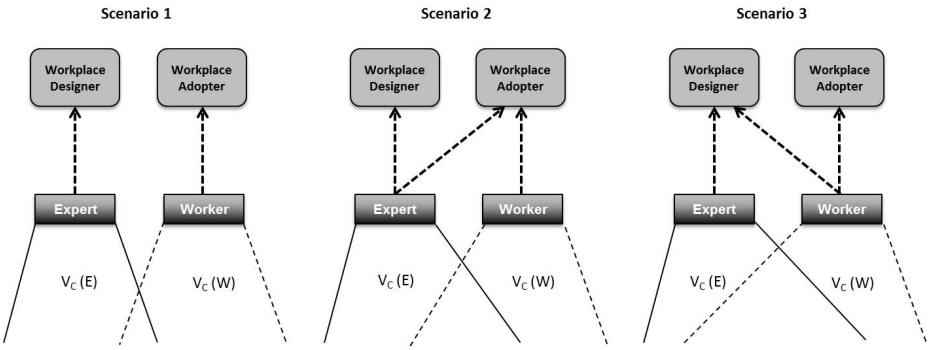

Fig. 6. Three scenarios based on assigning different roles to subjects, with different consequences for the alignment of the contextual view constructed by the expert ($V_C(E)$) and the contextual view constructed by the worker ($V_C(W)$)

The separation of responsibilities in Scenario 1 can be justified based on the different training and experience of experts and workers. Experts have knowledge in the formal analysis and design of workplaces with respect to business goals, while workers are trained in using the workplace for performing operational tasks. However, in such a scenario the contextual views across the two roles are typically not well aligned. For example, a production worker may have specific knowledge about the workplace (e.g. the manual handling of a specific work piece may require high physical effort by workers) that an expert may not have but that is relevant for achieving certain process requirements (e.g. health and safety goals). Critical for aiding context alignment in Scenario 1 is the quality and frequency of communication between experts and workers, as described in the subject interaction diagram in Fig. 5. Establishing a systematic information exchange between them, in regular intervals, may lead to a more people-centred process of workplace design and an increased contextual view alignment.

Another scenario, labelled "Scenario 2" in Fig. 6, can be seen as an extension of "Scenario 1" in that the Workplace Adopter is now associated not only with the worker but also with the expert. Here, experts *"put themselves in the shoes"* of workers, e.g. by following the workers going about their work or even by executing some of the workers' tasks. Immersing themselves in the same work environment as the workers allows the experts to gain direct experience of the effects of different workplace designs (e.g. the high physical effort involved in handling a work piece) and thus to enhance contextual view alignment with the workers for improved workplace design (e.g. automated handling of work pieces). This technique is more generally known as empathic design [19].

A third scenario, labelled "Scenario 3" in Fig. 6, expands the responsibility of workers to include not just workplace adoption but also workplace design. While there may still be an expert assigned to the Workplace Designer to assist in developing finer-grained details of design decisions, workers can autonomously change workplace designs to better suit their individual needs. This is similar to approaches such as mass customisation that defer some design decisions to the user of a design [20]. The contextual views tend to be well aligned in this scenario based on the close fit between the designed workplace and its adopter. In the production example, the worker may develop own ideas to improve work piece handling, such as modifying the order of assembling the work piece to produce sub-assemblies with reduced physical weight.

We believe that empowering workers to take an active role in workplace design is a first step towards integrating *context-as-interaction* into business processes (see also Section 2). Empowerment refers to a form of employee involvement initiative focussing on task-based involvement and attitudinal change [21, 22]. Workers have the first-hand knowledge necessary to decide which contextual aspects are relevant to a particular activity at a given time. They know about the setting, instances of actions and parties involved in a particular activity.

Experts in their role as workplace designers can provide a frame of reference in terms of representational context. They may suggest which information might count as context based on their own contextual views and provide a system for encoding and representing this information. But for context to have a real impact on making business processes more flexible and efficient, this information must be confirmed in an interactional way based on the real-life experience of the workers. Traditional approaches of business process modelling support the separation of responsibilities according to "Scenario 1". To enable "Scenario 2" and "Scenario 3" one has to enter new territory. Our proposed framework can be seen as a set of practices to support structural as well as psychological empowerment at work [22]. With its subject-oriented model of interactional context in business processes, it is a first step into this direction as outlined in this Section. It supports structural empowerment at work enabling participative decision making with respect to changes in the work process. Furthermore it opens the upward flow of information for improvement ideas as well as enables employees to build knowledge, skills and abilities. Giving employees the possibility to take initiative empowers them also in terms of competence to perform work activities using their skills. Additionally workers can improve their

self-determination in initiating and regulating their actions and impact, being able to influence e.g. operating outcomes at work, which also addresses dimensions of psychological empowerment.

5 Discussion

Developing a common understanding of what is and what constitutes context has been a difficult endeavour for researchers across various IT domains. The brief overview of related work in this paper indicates that differences in understanding and representing context also prevail within the business process management community. Yet, what most current approaches have in common is the *context-as-representation* perspective: Context is viewed as a static, pre-definable set of aspects that can be represented independently of its use. This understanding of context has only limited potential to be useful for process applications beyond standardised and highly automated operations. When human workers are involved having their own views of context, discrepancies with the process expert may occur that can undermine the acceptance of processes and lead to decreased motivation and work performance. The idea of *context-as-interaction* as proposed by Dourish [12] and others can augment current approaches by providing a process through which both process experts and workers can align their individual views of context.

This paper proposes a framework for this idea, formalised using a subject-oriented model. It allows describing different scenarios based on assigning experts and workers to either workplace designers or workplace adopters. Each of these scenarios has different effects on the expected alignment of individual contextual views. Of particular interest are the scenarios in which experts are assigned to workplace adoption and workers are assigned to workplace design, as they depart from the traditional, isolated role assignments and can strongly enhance contextual view alignment. Theoretical groundwork for these scenarios is provided by existing work in design science (such as empathic design [19] and user innovation [20]), organisational behaviour, and job design. These approaches may be used as conceptual input for developing new techniques supporting the alignment of context in business processes. Our preliminary investigations in this area concentrate on tools supporting the workers to act as workplace designers. These tools

- increase the awareness and reflection of workers on their workplace through using sensor technology and psychological methods of job design,
- raise issues concerning different workplace designs through the use of contextual design tools to capture interactional context information and providing a platform for real-time postings, and
- facilitate the empowerment of workers as workplace designers based on S-BPM as a simple and intuitive modelling notation.

The development of these tools and two case studies for the implementation and evaluation are part of an on-going European research project on people-centred production workplaces (www.so-pc-pro.eu).

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