A Semantic Model for Small and Medium-sized Enterprises to Support Organizational Learning

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Abstract: Many efforts have been made in the last two decades to manage knowledge in organizations, especially tacit knowledge which is difficult to transfer to others as contrary to explicit knowledge. Organizational learning plays a great role in capitalizing such expertise in organizations. Large enterprises can spend high budgets on the organizational learning process which is not the case in Small and Medium-sized Enterprises (SMEs) where organizational learning is not supported due to the missing of standardized and codified technical supports. So there is a special need for SMEs to organize their knowledge and to facilitate the access of information. In this paper, we present the Organizational learning and its specifications in SMEs. We also present TOVE and Enterprise projects from which we defined a semantic model specially dedicated to SMEs. We explain the choice of the MEMORAe organizational memory platform to manage knowledge in SMEs.

1 INTRODUCTION

Organizational learning is a property which emerges from sharing knowledge and practices of the members in an organization. It is an accumulative process based on an organizational knowledge resulting from the accumulated experience. In order for this knowledge to be shared all over the organization, it must be communicable, consensual and integrable (Duncan, 1979). According to (Chen et al., 2003), being communicable means that knowledge must be represented in an easily comprehensible and distributable way. Being consensual implies that this organizational knowledge must be valid and useful for all members of the organization. Being integrable means that its representation could be saved in an organizational memory which must be consistent, accessible and well maintained. The process of organizational learning is affected by the size of the organization. In Small and Medium-sized Enterprises (SMEs), the expertise is limited to a small number of persons and to only one individual in some cases (Nicolas, 2003). As a consequence, there is a strong dependence on some actors of the organization. The smaller an organization is, the more we recognize an increment of the relative "weight" of each individual (Mahe de Boislandelle, 1996). As a result, it is difficult to transmit know-how and know-why knowledge, managing the

turnover and integrating new knowledge to the organization. Most of the research studies have focused on the process of learning within the large organizations (Thorpe et al., 2005) and has not been done much on small organizations where the organizational learning faces a lot of difficulties. This paper will focus on the organizational learning process in a special type of organizations called SMEs following a knowledge engineering approach in order to develop a collaboration platform dedicated to organizational learning in SMEs.

In sections two, three we define the organization and the organizational learning respectively. "Tour Equipement" case study and the details of MEMO-RAe platform are described in section four. Related works, mainly TOVE and Enterprise projects, are presented in section five. We propose a model and a complete usage scenario in section six.

2 WHAT IS AN ORGANIZATION?

2.1 General Characteristics

(Weber et al., 1978) views the organization as a set of constraints on the activities performed by its agents. Max Weber believes that all organizations have a well

defined hierarchy with levels controlling sub-levels. Every employee must have the competency to accomplish the task to which he/she was employed for. Rules and regulations must be implemented in the organization to avoid the management based on self-interest and personalities. This implies an impersonal relationship between managers and employees which will facilitate the decision making procedure and the evaluation of the employees' outcomes.

2.2 Small and Medium-sized Enterprises (SMEs)

According to The European Commission (EC), an enterprise is considered medium-sized if it has less than 250 salaried, and small-sized if it has less than 50 salaried. In addition, there are two other criteria to choose from: either the annual turnover must not exceed 50 million euro or the total balance sheet must not exceed 43 million euro (Commission Recommendation of 6 May 2003).

3 ORGANIZATIONAL LEARNING

The dictionary definition of learning is the acquiring of information, knowledge or skill. (Argyris and Schön, 1978) differentiates between two types of learning: single-loop learning and double-loop learning. The single-loop learning is based on the detection-correction principle. This means that a modification of actions is made according to a comparison between the desired and the obtained outcome. The double-loop learning happens when the entity is able to view or modify all the assumptions, policies and values that led to the specific action (the root cause of the action). In an organizational context, there are two levels of learning: 1- operational which is a single-loop learning that consists of correcting actions to obtain better results, 2- management which is a double-loop learning that involves the correction of errors at a higher level. If we take the example of a team in an enterprise having problems in meeting the project deadline. Increasing the working hours per day could be an example of single-loop learning. Although there is a slight improvement, the investigations showed that the team structure and communications between each other also affects the team not meeting the deadline. It is therefore this issue that is the root cause of the problem (double-loop learning).

3.1 SMEs Specifications

The process of organizational learning is affected by the size of the enterprise and according to (Nicolas, 2003) the organizational learning within small structures is very specific and needs a non-traditional approach. We notice a direct supervision and coordination in SMEs which is contrary to large enterprises where the coordination is procedural and codified. The standardized and codified technical supports (numeric or paper versions) which are present in large enterprises support the process of organizational learning. Such standardized technical supports are missing in SMEs. In addition, the interaction is more codified in large enterprise (e.g. regular group meetings) than in SMEs.

A way of learning in SMEs is explained in (Lima and Filion, 2011) who considers SME as either a behavioral system or an interpretation system. In a behavioral system, the members' short-term behavior is affected by the feedback of impacts generated from other members' action. In an interpretation system, the members search for information throughout the enterprise's environment, interpret this information and learn by generating knowledge.

(TSAI, 2009) view that there are three aspects to take into consideration for organizational learning in SMEs: individuals (especially the owners-managers), internal routines and external networks. Firstly, the owners-managers play a big role in the enterprise. They are responsible for the decision making and their knowledge has an impact on the internal and external learning resources. Secondly, the internal routines also affect the learning process in the enterprise. These routines include organizational culture in addition to the internal relationships. Finally, external networks include all external resources that influence the organizational knowledge.

(Gray and Gonsalves, 2002) divided the organizational learning in SMEs into three dimensions. The first dimension is Personal Cognitive Learning (PCL) which includes all enterprise activities that consider the members as individual learners. It focuses on the knowledge that resides in individuals' minds. Its content mainly comes from what members already know and their past experiences. The second dimension is Social Constructive Learning (SCL). It includes all enterprise activities that consider the members as social individuals. In this case, members share their knowledge in every day communications and interactions with other members of the enterprise. The third dimension is an extension of the second one. It is the Institutional Constructive Learning (ICL). In this dimension, knowledge is developed when enter-

prise members take part in the construction of something external to themselves or considered universal' to their enterprise (e.g. formal procedures, organizational charts, support systems, authority structure).

3.2 The Need for Organizational Learning in SMEs

The following summarize why do SMEs have a special need to implement the organizational learning:

- Individuals in SMEs can play different roles at same time because of their small number. For example, a member can be both a technical manager and designer. This results in a high dependence on members in the enterprise which makes their replacement very difficult and critical to the enterprise.

- Direct supervision and coordination is found in SMEs due to the small size. In addition, oral communication is present between members. As a consequence, the codified and standardized supports are missing and are only present in the actions of the enterprise members. So there is no trace of what had been done or decided for a particular issue.

The two previous points illustrate that there is an urgent need to organize the knowledge in SMEs. The knowledge must be codified and easily accessible by the members at any time.

4 "TOUR EQUIPEMENT" CASE STUDY

"Tour Equipement" is a small enterprise (14 salaried) in the Picardy region, France. It has more than 50 years of experience in the mechanical production. Our team visited the enterprise to take a close look about all processes in order to precisely identify the need for organizational learning in this enterprise. All examples in this article will be based on "Tour Equipement" enterprise.

4.1 The Choice of MEMORAe Approach

The MEMORAe approach defines a model and an environment to manage all heterogeneous resources of knowledge in an organization. MEMORAe uses an ontology-based reference called (mc2) to support knowledge capitalization in an organization. Following a knowledge engineering approach, the resources

are organized in an organizational memory based on ontologies (Abel et al., 2004). It views the organization as a set of individuals organized in groups in order to exchange information resources and share knowledge via documentary and social resources indexed by "job specifications". Knowledge may be accessed from different workspaces and according to different viewpoints. mc2 is represented using the OWL (Ontology Web Language) which is a W3C (World Wide Web Consortium) standard. In such language, we are able to define concepts and relations between these concepts. mc2's main interest is to model the resource sharing in an organization. It focuses on resource concepts, groups of individuals and the sharing spaces in which we can share a specific resource. mc2 ontology model makes use of three other ontology models (Deparis et al., 2011):

1. Sioc (Semantically-Interlinked Online Communities): It aims to enable the integration of online community information.

2. Foaf (Friend of a friend): It describes persons, their activities and their relations to other people and objects.

3. Bibo (Bibliographic): It describes the bibliographic resources.

4.1.1 MEMORAe Platform

E-MEMORAe 2.0 is a web platform that follows MEMORAe approach for resource sharing. One of the strengths of MEMORAe platform is its complete integration of all the features needed to host a server for collaboration and knowledge capitalization. It is not a combination of different software that offers the desired functionalities. A semantic map (see figure 1) is presented to access private or shared resources from a formal or informal process within individuals' group (team, department, project organization, etc.). The use of a semantic map allows us to define a common reference in which it is possible to navigate and to access the capitalized resources in different spaces according to their semantic description. Any resource can be indexed by its content (the concepts it addresses) or its meta (author, creation date, etc.). The knowledge map represents a semantic back-bone/reference. The semantic backbone links working space with social and learning space. The focus on the map allows the users to view in parallel all the resources that it indexes distributed in the sharing spaces which are accessible by the user. These resources may come from a chat, a document, a wiki, a calendar, etc. The platform has sharing spaces that display a set of shared resources by the members of

this space. Each user has a private space, only accessible by him. The parallel view of sharing spaces facilitates the transfer of resources from one sharing space to another by means of "drag and drop". The same resource can be visible in different spaces, however it is stored in a single place. MEMORAe platform was chosen because it supports the organizational learning by focusing on resource exchange and knowledge sharing via documentary and social resources indexed by job reference. On the other hand, this approach did not take into account other aspects of the organization. For example, it does not model the organization hierarchy structure, or the activity of the organization. For that reason, we aim to exploit TOVE and Enterprise projects that study different aspects of the organization including the resource itself.

4.1.2 Organizational Learning based on Document Resource Annotation

The annotation of documents plays a great role in knowledge capitalization. An annotation is a note associated with a particular target. The target can be a collection of documents, a document or a document segment (a paragraph, a group of words, an image, etc.). From the point of view of psycholinguistics and cognitive scientists, annotation is a trace of the mental state of the reader and a record of his/her reactions face-to-face with the document. So the annotation turns the "reader" into an "active reader". MEMORAe approach adopts the annotation as a way of expressing tacit knowledge like thinking, judgment, opinion etc. For example, the product specifications document can be annotated, discussed and sent to the agent who has the appropriate role to start or achieve the manufacturing activity. This later agent may place all the commands to supply the resources needed for the manufacturing activity based on exchanges between individuals: Who is talking to whom? Who shares what with whom? Who can intervene in the process and with which role? Each human agent must leave a trace of choices and reflections emitted during the activity. All members as belonging to the same group can exchange their knowledge to improve the manufacturing process.

On the other hand, MEMORAe is not oriented to a special type of organization. As a consequence, for SMEs, it does not take into consideration the structure of the organization (roles and authority), activities and plans, machines as part of SMEs manufacturing process, marketing and strategy, product quality and cost and juristic representation. Taking the machines as an example, they participate in the manufacturing activity as being resources to it. The way of representing a resource machine as an object that participates in

activities is not present in mc2 model.

5 ENTERPRISE MODELING

According to (Fox and Gruninger, 1998) An Enterprise model is "a computational representation of: structure, activities, processes, information, resources, people, behavior, goals, and constraints of a business, government, etc."

Two major enterprise models have been studied: The "TOVE project" (TOronto Virtual Enterprise) and the "Enterprise project".

5.1 TOVE (TOronto Virtual Enterprise)

The TOVE project is first proposed by (Fox, 1992) who outlined the goals of TOVE project in four points:
"

1. It provides a shared terminology for the enterprise in a way that every application can understand and use.

2. The first-order logic is used to define the meaning (semantics) of each term in a precise and an unambiguous as possible manner.

3. The PROLOG ((PROgramming in LOGic) axioms are used to implement the semantics in order to enable TOVE to automatically deduce the answer to many commonsense questions about the enterprise.

4. It defines a symbology for depicting a term, or the concept constructed thereof, in a graphic context. "

TOVE models the enterprise as a set of integrated ontologies. Currently these ontologies are:

1. Activity, time, and causality (Gruninger and Pinto, 1995) (Gruninger and Fox, 1994)

2. Resources (Fadel et al., 1994)

3. Cost (Tham et al., 1994)

4. Quality (Kim et al., 1994)

5. Organization structure (Fox et al., 1995)

6. Product (Lin et al., 1996)

5.2 Enterprise Project

The role of the enterprise project as specified in (Uschold et al., 1998) is to act as a communication medium between:

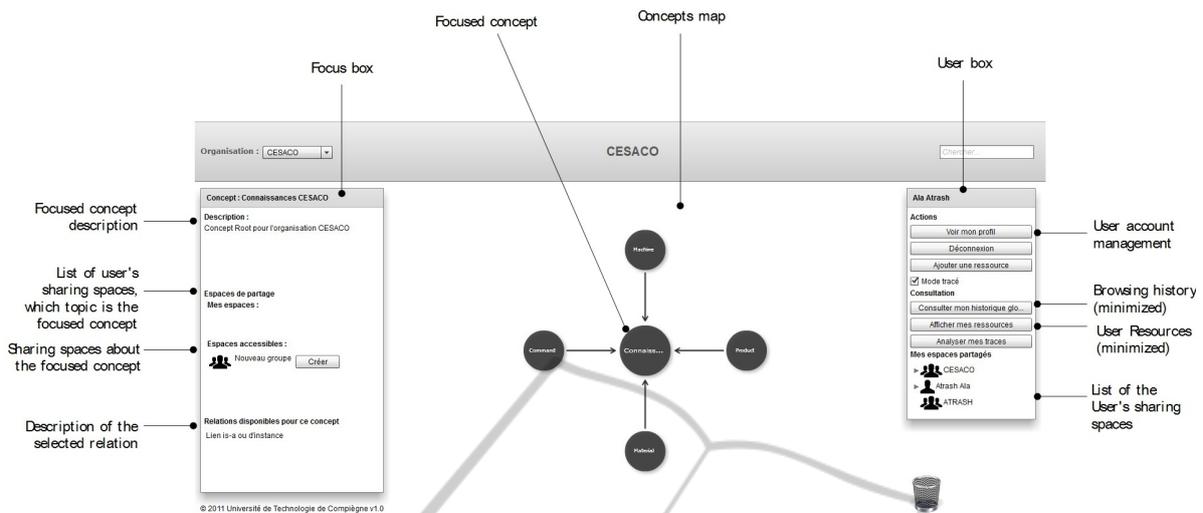- People across different enterprises.

Figure 1: The semantic map in MEMORAe platform.

- People and implemented computational systems.

- Different Implemented computational systems (like DBMS (database management system) for example).

The enterprise model defines the concepts that could be found in an enterprise and all the relations between these concepts. Enterprise ontology model is divided into five main sections:

- Meta ontology and time: The concepts of Meta ontology are used to describe other concepts in the ontology in addition to time.

- Activity and processes: These concepts describe everything in the enterprise that concerns activities.

- Organization: The main two concepts defined here are Organization Unit (OU) and Legal-Entity.

- Strategy: This concept is related to strategic purposes and goals that the enterprise aims to achieve.

- Marketing: This concept defines everything which is related to sale (e.g. market, customer, product etc.).

6 A SEMANTIC MODEL FOR SMEs

We aim to enrich (mc2) model with new concepts that meet the needs of SMEs. We started by resources and activities as they are essential to the enterprise. We took into consideration the definition of these two concepts in TOVE and Enterprise projects.

6.1 Resource Modeling

We are interested in all types of resources in SMEs as being an element key in the modeling process. mc2 considers the resource as a "vector of information". There are two types of resources in mc2 ontology: simple resource (SR) and composite resource (CR) (see figure 2). A document (e.g. a note) can be a direct example of SR. An agent is also considered as a SR because the agent can provide knowledge. CR is composed of other resources (e.g. note cluster may be composed of other notes or note clusters). The annotation is also represented in mc2 as being a SR. The annotation has a content, a recipient and a type. The type can be either a comment, an explanation, a reference or a question. The annotation concerns any resource and is added by an agent. Our contribution to the ontology model started by defining the material resource (MR) concept which is essential to SMEs. We defined the MR as resources that have physical existence. The MR is considered to be a SR (see figure 3).

The MR has can be specialized to the following concepts:

- ManufacturingResource: Resources that play a certain role during activities, e.g. Machines can have a specific role during activity (saw machines are used to cut the metal during the manufacturing activity).

- ConsumedResource: Resources that can be consumed during activities, e.g. raw materials that can be consumed during activities (metal is a raw material that is consumed during the manufacturing activity).
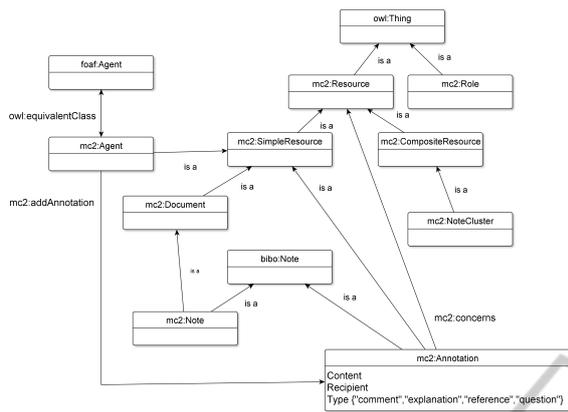
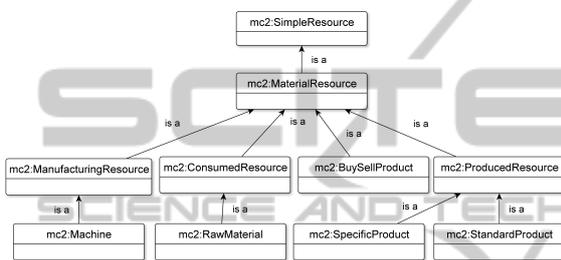Figure 2: mc2 resource and role ontology.

Figure 3: The material resource.

- BuySellProduct: Products which are bought by the enterprise to be sold by the SellActivity for profit purpose.

- ProducedResource: The products produced in the enterprise itself by the ManufacturingActivity to be sold by the SellActivity. There are two specifications of such resources:

  1. StandardProduct: All the parameters of the product are already specified by the enterprise.
  2. SpecificProduct : The product is manufactured according to user-specific parameters.

6.2 Activity Modeling

The Activity concept is also added to mc2 ontology model as it so important to SMEs (see figure 4). The Activity is defined as processes and procedures done over time. Every activity requires at least one role to be preformed. In addition, the activity may be composed of sub-activities. The Activity has the following data properties:

- Duration: The duration of the activity (year-month-days-hours-minutes)

  Specifications of Activity can be:

- ManufacturingActivity: The activity of manufacturing a product.

- SellActivity: The activity of selling a product.

- BuyActivity: The activity of buying a resource.

The role concept which is present in mc2 describes the way of participation in an Activity. This role can be played by an Agent or by a ManufacturingResource (see figure 5). The relations between activities and resources are presented in figure 6.

6.3 The Scenario of Manufacturing a Product in "Tour Equipement"

This scenario is based on PLM (Product Lifecycle Management) principles. The processes of PLM can be summarized to: Planning, Design, Realizing, Sell and deliver. The technical manager receives the client requirements either by mail or by phone. The technical manager then writes down all these requirements to a numeric document (mc2:document) and shares it either with himself (in his personal sharing space) or with other members of the enterprise (e.g. the production manager). The document may be annotated (mc2:Annotation) by the technical manager or any member who has access to it. This annotation may be a comment (e.g. the requirements concern a specific/standard product.), an explanation (e.g. explain an ambiguous point in the client description), a reference (e.g. a reference to a similar product specifications) or a question (e.g. what should I do here?). If it concerns a specific product (mc2:SpecificProduct), the technical manager makes the product design using a computer aided design CAD software (e.g. SolidWorks). The technical manager shows the design and the planning to the client. If the client validates the technical manager proposition, the requirements are translated to a command and the manufacturing activity (mc2:ManufacturingActivity) starts. This activity requires a role (mc2:role) to be performed (e.g. a worker). It involves a manufacture resource (mc2:ManufacturingResource) like machines (mc2:Machine). In addition, this activity consumes raw materials (mc2:RawMaterials) as being consumed resources (mc2:ConsumedResources). During this activity, any member can add annotations that concern the machines signaling that a machine is broken down, slow or not suitable for a specific task, etc. Annotations may concern raw materials (e.g. their quality, compatibility). Agents (mc2:Agent) as being resources may also be annotated. Agents annotations are not judgments but rather comments denoting agent's experience or competences. When the manufacturing activity is finished, the product is sold to the client by means of the sell activity (mc2:SellActivity).
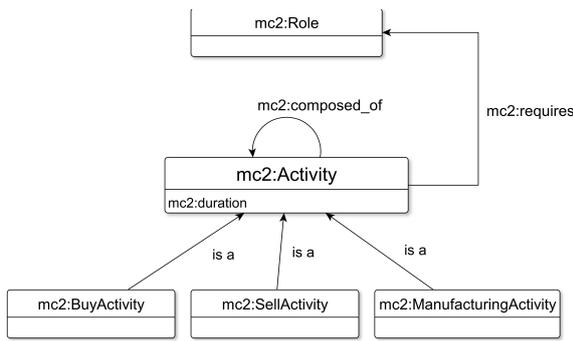
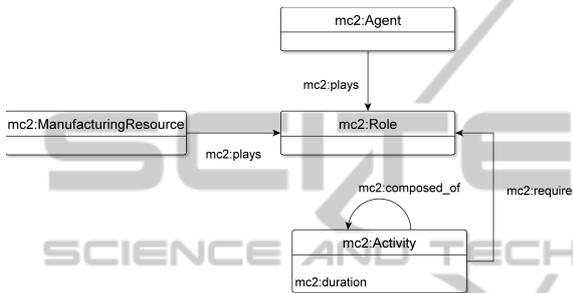Figure 4: Adding the Activity concept with its sub-concepts.
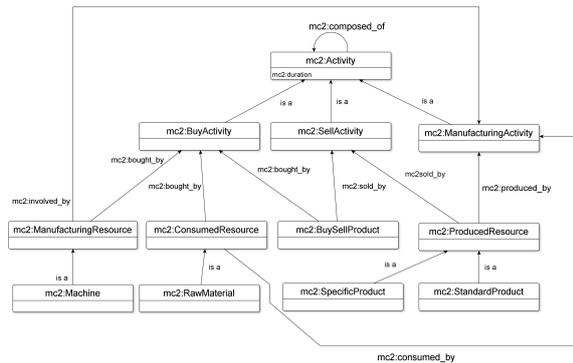

Figure 5: The representation of role.

Figure 6: The relations between Activities and resources.

6.4 The Usage of MEMORAe Platform

To take a concrete usage example, let's suppose that the technical manager receives a phone call from Mr. Anderson (a client) demanding 6 collet chucks for his enterprise to be delivered within 2 months. The technical manager takes the notes either directly using MEMORAe platform to share them in a specific sharing space, or by using a tablet application (developed in our laboratory) that allows the users to take local notes and then send them to MEMORAe platform when needed. When the user of the tablet application decides to capitalize his/her local notes and send them to MEMORAe platform, he/she has to determine: 1- the concept by which the note will be in-

dexed (e.g. the "collet" concept), 2- the sharing space in which the note will be shared (e.g. his/her private sharing space). This note is then accessible in the MEMORAe platform either by the sharing space or by accessing the "collet" concept and making it as the focus concept of the semantic map. So the technical manager can retrieve in the future his/her notes that concerns a particular concept. MEMORAe organizes the knowledge in the enterprise. Now all the notes that were taken during the manufacturing activity are accessible as being knowledge resources. In addition, the process of annotating resources (e.g. machines, agents, raw materials, documents, etc.) to be shared plays a great role in knowledge exchange and keeps a trace of all the decisions that were taken facilitating their retrieval in the future. For example, if the technical manager in "Tour Equipement" takes paper-based notes that concerns the client command, he/she will not be able to easily retrieve these information specially if there is not a good archive system (which is the case in most SMEs). So MEMORAe platform gives us the ability to save and share the notes in order to keep a trace of what happened in the enterprise.

7 CONCLUSIONS

The organizational learning in SMEs meets many difficulties and needs a special and non-traditional approach. We proposed an IT platform that facilitates knowledge sharing and retrieving between individuals. In addition, this platform is supported with an annotation tool that keeps a trace of all the notes taken concerning a particular resource in the enterprise. We also extended our model to meet new requirements of SMEs (material resources and activities). A test of the platform is scheduled to be in November 2013 in "Tour Equipement" enterprise. Further work would be done by enriching our platform with many tools and adding extending the model to capture new concepts like cost, quality, authority and skills.

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