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CMPAAS – A PLATFORM OF SERVICES FOR CONSTRUCTION AND HANDLING OF CONCEPT MAPS

Davidson Cury, Wagner Andrade Perin & Paulo S. Santos Jr, Universidade Federal do Espírito Santo, Brasil
Email: dedecury@gmail.com

Abstract. Concept maps are popular today and they have been used to support different activities, where knowledge needs to be organized and represented, particularly in learning activities, either in academy or in the corporate world. However, they are not used as they should for different reasons. In this paper we have pointed out some of those reasons and we also present an environment that, we believe, has a great chance to be a good solution. That environment consists of a service-oriented platform whose objectives are: transforming academic works in affordable computer services to the community in general and provide mechanisms that allow the community to create, extend and integrate new services or functionalities to the proposed platform.
Keywords: concept map, portal of knowledge, platform of service.

1 Introduction

Concept maps have been used in several educational activities that comprise teaching and learning. In fact, their applications are being explored and have shown advantages both, in planning pedagogical activities (Hartmann *et al.*, 2014), and in the monitoring and assessment of learning (González, 2001). Likewise, they have been used as a tool for organizing and building knowledge, regardless of the domain of application. More recently it begun to be used as a tool for knowledge representation in a way that can be computationally interpreted or processed (Cañas *et al.*, 2000, 2008).

We agree with Novak & Gowin (1984) who define a concept map as a graphical tool to represent and organize knowledge in two dimensions, using concepts distributed in such a way that the relations between them are evident. On a map, the concepts are nouns and the links are verbal structures. Each triple (concept, connection, concept) forms a semantic unit, the smallest unit of information present in a concept map, which we call proposition. The propositions constitute the basic feature of concept maps, which distinguishes them from other similar representations (Dutra *et al.*, 2007).

Novak supports his definitions on the basis of Ausubel´s Meaningful Learning Theory (Ausubel, 1968). According to this cognitive theory, a mental structure of knowledge is hierarchically organized, in a tree like shape, where concepts that are more general are at its highest levels, near the root, while concepts that are more specific are at lower levels.

Concept maps are popular today and are used to support different activities, in which knowledge needs to be organized and represented (Gava *et al.*, 2003), particularly in education (Dutra *et al.*, 2004). In human activities, we are driven by the curiosity to know the similarities and / or differences between concepts. We are also led to compare, generalize and even to merge or generate them automatically. However, if we assume a constructivist approach, we can bring some issues to this trend of computerization and automation: is meaningful learning aided by this technology? Will the available resources contribute to true improvement of the mechanisms of assimilation and accommodation of knowledge? (Souza *et al.*, 2007).

If we think of tools to support education, the maps herein are milder to the use and understanding. Countless times does a teacher make use of maps to check the level of understanding of the student for a given topic or wants to see the average knowledge of a classroom. If the maps are automatically generated, the teacher can refer to them to assess their fidelity to the domain or text that gave rise to them. Through a map editor, he/she can add or undo constructs with great ease. When learners work in small groups and cooperate to learn a given subject, they achieve favorable cognitive and affective outcomes.

Among a huge number of applications, concept maps help students learn more meaningfully help teachers to indicate visually key concepts and summarize their interrelationships, and also assist groups in collaborative tasks. In the latter case, they aid communication between team members and in the management of project development. Concept maps also facilitate the understanding of the subject by each learner.

However, the academy is not the only sector of society interested in applications and tools aimed for editing, manipulation and analysis of concept maps. In business, there is also great interest in the creation and use of these tools. As an example, there was a considerable increase in the production of computational tools for the automatic construction of maps, directly from data sources such as unstructured texts. In fact, most of the approaches (10 out of 15) to automatically constructed concept maps were published in the last three years (Kowata *et al.*, 2009).

Since concept maps motivate both, industries and the academy, what prevents the most rapid development of research and technological solutions in this domain? Two possible problems affect both, the academy and corporations, thus requiring efforts to minimize them: (i) fragmentation of the research and, consequently, (ii) limitation in their evolution and application. .

By "fragmentation of research", we mean a real separation between the solutions developed, sometimes even done by the same research lab. Let us take, for example, the following solutions: an automatic generator of concept maps (Kowata *et al*, 2010), an environment for building and versioning concept maps (Santos *et al*, 2005), an environment for automatic evaluation of concept maps (Gava *et al*, 2003), a tool for comparing concept maps (Lamas *et al,* 2005), and a solution to increase the cohesion and coherence in concept maps (Ribeiro *et al*, 2011). All these studies were carried out by the same laboratory, and culminated in the creation of technological tools that assist, each one in its specificity, the use of concept maps. However, despite having points in common, the tools developed by these researchers are not able to communicate, i.e., do not compose a set of tools capable of defining a complete solution to support the use of concept maps. Therefore, since they are not integrated, they become inaccessible to general users who usually want to perform different tasks with concept maps.

In the same context of research fragmentation, Lourenço (2008) presents an approach to the analysis and evaluation of conceptual maps. In his work, it is possible to envisage a number of computational tools that can assist the author in the data collection process and in the composition of the statistics presented. However, the development of such tools may not be feasible because it might require the development of a complete environment, with user authentication, a system for the managing and editing of concept maps etc. Since the studies tend to be too fragmented, their development and reuse call for reconsideration. The practical result of this fragmentation is observed when pedagogical approaches based on concept maps are put in practice. In some cases, there are no computational solutions that help teachers in their analyses and assessments, whether statistical or cognitive, bringing about a heavy load of cognitive and manual processing.

An equally serious problem is the fact that the community in general and the academy seem not to be speaking the same language. After all, why does the community in general have so much difficulty in accessing the research and their results fast and easily? We consider it important to create a mechanism to facilitate the access to the results of scientific research, so that the community can contribute to their evolution. What we propose, thus, is launching the bases towards a closer interaction between the academic world and society in general.

Therefore, in this study we emphasize the need for adoption of development techniques to facilitate the reuse of existing results in the short term. For this, we propose the creation of a service-oriented platform whose objectives are: (i) transforming academic works in affordable computer services to the community at large and (ii) provide mechanisms that allow the community to create, extend and integrate new services or functionalities to the proposed platform.

For the presentation of this platform, this paper is organized into four sections. The first aims to present the context of the problem as well as the organization of the article. The second aims to present the main features of the concept maps. The third section provides a description of the architecture of the proposed platform. Finally, the fourth section presents some conclusions and points to possible future works.

2 Why Concept Maps?

From experience we can state with a high degree of certainty that there are countless contexts in which concept maps may serve as a very useful tool. In general we start from a text to obtain an its equivalent map. However, we can also do the opposite, i.e., go from a map to generating a text. It is clear that the maps do not replace texts

but are a good start to their construction. From a single map, various texts can be generated, depending on the view and interpretation of each reader.

We are interested in exploring and enhancing the many positive characteristics we observe in concept maps. In Table 1, we list some general advantages of the maps in relation to the text in different contexts.

Table 1: Common uses of concepts maps.

General Characteristics	Areas of Use	
	Teaching-Learning	**Global Community**
They are easy to read and construct.	They show the meaningful relationships between the concepts of a lesson, a unit of study or a course.	Maps allow to record meetings minutes.
They soften the process of making tacit knowledge explicit by not requiring very strict formats (grammar).	They represent the conceptual frameworks being discussed in an organized manner, facilitating the presentation and learning of these structures.	Maps allow for the organization of the knowledge of a company or any other institution.
They help students learn how to learn, i.e., that learning builds, corrects and expands prior knowledge.	They work as a short term memory, reminding the teacher and the student of the key concepts, their relationships.	Maps allow indexing concepts, among other tasks.
They enhance the retrieval of information and its application in new contexts.	They allow for recording information.	Maps can replace organograms reasonably well, allowing both, for the structuring of a team, as well as the establishment of subordination and responsibility for each of the members.
They are Non-sequential	They can be used to identify the student's prior knowledge and relate it to new knowledge.	
They help indicate that problem solving usually requires the organization of knowledge relevant to the problem.	They help students and teachers to identify malformed concepts, especially when students work in groups.	
They allow students to feel free to build,reinvent, receive and respond to challenges as well as expressing their inner world.	For involving collaborative learning, they enable: 1) students ,both, individually, and as a group, to observe and analyze the articulation, organization and critical evaluation of the whole process of knowledge construction; 2) teachers to monitor and evaluate the progress of each student's knowledge and of a working group, by observing their maps.	

We also highlight concept maps application in early childhood education, when they are suitable for children with difficulties in constructing sentences. And, because they are ludic, they encourage and facilitate them to express their ideas.

3 CMPaaS: The platform

When dealing with the development of computational solutions, the subject in vogue in recent years is undoubtedly cloud computing. This is a computing model in which processing, storage and computing solutions (software) are offered by a service provider accessed remotely via internet. This technology allows the use of applications and the retrieval of information from anywhere, from any platform, at any time, using the web instead of locally installed applications.

The main advantage offered by cloud computing is its ability to be easily extended and incorporated into other applications, increasing productivity when creating new applications. Because of this, the big tech companies and social networks (e.g., Facebook, Apple, Google, Twitter etc.) have their services available in this model of computing. Just to cite one example, a cloud application used extensively is Google Maps. Today there are countless applications that extend their functionality offering complementary services, such as geolocation applications that control the route, pace and calories consumed by an athlete over a physical activity, available in most current smartphones. It is precisely this capacity of expansion and productivity that we are exploring in

this project. We are creating the basic editing services, management and manipulation of concept maps that will be available to anyone in the world through our platform of services.

We call the proposed service oriented platform *CMPaaS* (Concept Maps Platform as a Service). One of the fundamental features of the architecture being used in this project, known as SOA (Service Oriented Architecture), is its ability to promote integration. This means that new services that extend the functionality of the services offered by *CMPaaS* can be developed and made available by anyone, anywhere in the world. The promotion of this scenario of collaboration and integration between the academic community and enterprises is one of the central goals of this project.

We also want to point out that the platform services are being implemented as Web Services. Since this is a mechanism of internal operation, applications providing a user interface need to be utilized. Thus, the *CMPaaS* is associated with a portal named "Knowledge Portal" that serves as the interface for the use of the tools offered. In Figure 1 (a) one can see how the portal tools interact with the services provided by the platform, while Figure 1 (b) shows how the community can integrate its services with the internal services of *CMPaaS*.

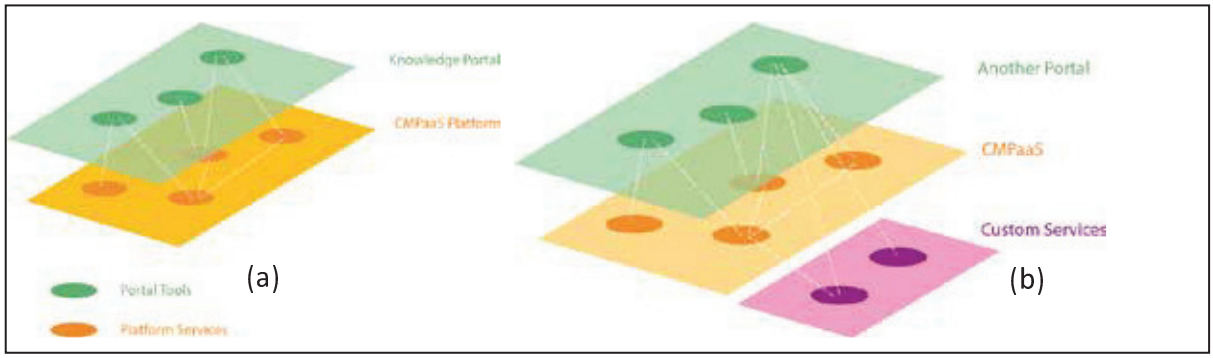

Figure 1: (a) View of integration of the knowledge portal with the platform. (b) View of integration of an external portal and services with *CMPaaS*.

As can be seen, the tools available on the portal are utilizing services of the platform. It is noteworthy that a single tool can be utilizing more than one service simultaneously. As an example, take the map-editing tool. While a user edits a map, the editing service is working to provide the visual characteristics of the map to the editor. At the same time, the authentication service is active to inform which user is making changes to the map. And even more, the service versioning needs to validate each version of the map. We therefore have a unique tool utilizing three platform services.

A single service of the platform can also be utilized by various tools of the portal. As an example, we can mention the maps listing service. It can be used by the concept maps query tool as well as by the maps merge tool. Both scenarios demonstrate how this architecture allows for the integration of the tools. Following we will present more details of the internal architecture of *CMPaaS*. We will also describe its main components, services and tools as well as the current stages of development of the portal.

3.1 General Architecture of CMPaaS

Internally, the platform consists of four layers (Figure 2): (i) external services, (ii) business processes, (iii) services of the internal applications, and (iv) internal components. The External Services layer is responsible for providing the services that will be utilized by the community (e.g., government agencies, private entities and ordinary people). In other words, the External Services layer is responsible for performing the interaction between the external world and the internal world of the platform. The Business Processes layer is responsible for managing business rules of the platform. This layer serves for the implementation of the processes that manage all services provided by the platform. The Internal Service Application layer is responsible for managing the services used by the business processes. This layer provides for the services of the internal components for the processes of the platform. Finally, the Internal Components layer is responsible for managing the components that provide all the services of the platform. For example. in this layer are the components for managing the users and concept maps.

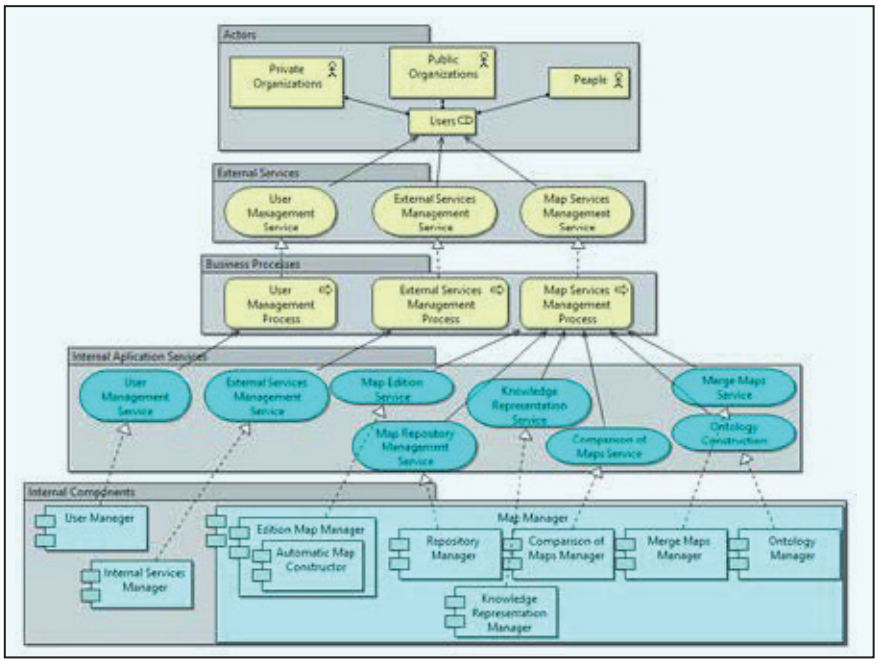

Figure 2: Functional view of the architecture of the platform *CMPaaS*.

Following, Figure 3 shows a simplified view of the major components of the overall architecture of *CMPaaS* as well as its interactions.

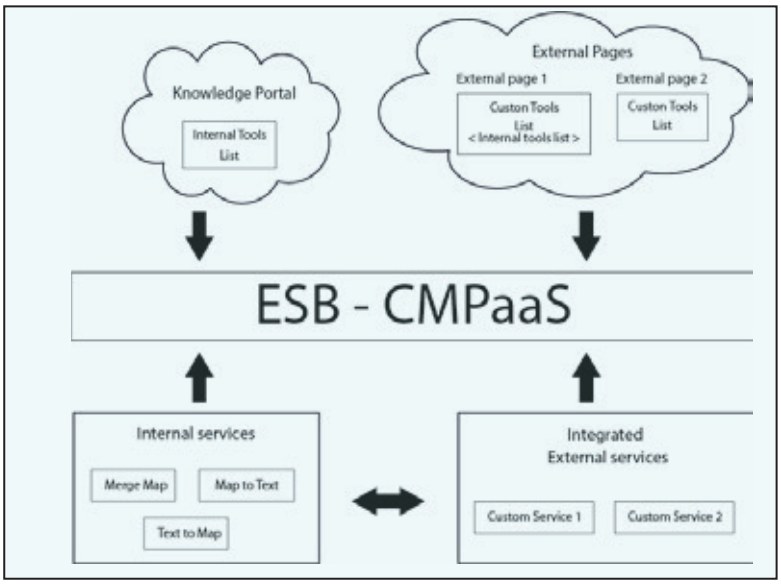

Figure 3. Conceptual architecture of *CMPaaS*.

As we can see there are three components in the architecture of *CMPaaS* which will be described in the following subsections.

3.1.1 ESB (Enterprise Service Bus)

ESB is the component of the architecture that provides the basis of services for more complex architectures via event drivers and patterns based on messages. It is responsible for providing an abstraction of layers in the implementation of the messaging system which allows the integration of architecture to exploit the value of messages, without the need to write complex code. This is the central component of the project because it aims to remove the coupling between services and transport.

3.1.2 Platform Services

Services are the features that will be provided by the platform for the presentation layer (the portal). These features include: user authentication, persistence and management of concept maps, analysis and manipulation services of concept maps, among others. It is worth noting that not all the services are of our own, since the general community can use the basic services provided by us and create new services that may be provided by them, or submitted to *CMPaaS* to become an integral part of our services. We call the services provided directly by *CMPaaS* internal services. The ones provided by third parties we call external services. It is noteworthy that all the services can communicate, integrating themselves with other services through the ESB.

Internal services are necessary functionalities for the management of users and their concept maps. These services form the kernel of the platform, i.e. they comprise the basic infrastructure of the platform. The external services are added to the platform services by the community, whether academic or not. Through these new external services the platform becomes extensible and dynamic. It is important to note that the processing of external services is initially not the responsibility of the platform. Such services shall be processed outside of the platform infrastructure. The platform only has the responsibility of managing the use of the services it offers.

Furthermore, with respect to the internal services, they are classified as: 1) platform management services and 2) basic services for constructing and manipulating concept maps. The internal platform management services are responsible for managing the users, the internal services (to add new users or new external services), and the services for map manipulation. The internal services for map manipulation are responsible for the basic functionalities for creating and manipulating the concept maps. Thus, within the context of this platform, the basic services resulting from academic projects and already defined and currently in development are:

- Concept maps edition service (S, 2005);
- Concept maps repository service (S, 2009);
- Concept maps comparing service (L, 2005);
- Concept maps merging service (G, 2014);
- Automatic concept maps generation (K, 2009, 2010);
- Service for generating ontologies from concept maps (P, 2010);
- Concept maps inference service (P, 2010);
- Service for automatic representation of Piaget´s knowledge classes (C, 2013).

Some of these services already show results that will be presented in other papers. Others are functional prototypes being gradually incorporated into the *CMPaaS* platform.

3.1.3 External Services

Another goal of this platform is to provide services to the community, with concern of the visual presentation of its tools. This is done in two ways: (i) knowledge portal and (ii) external pages. Through the portal of knowledge the community can access, in a simple and fast way, the internal services of the platform. In other words, the portal is a means by which the community (teachers, students and other stakeholders) can use the services of the platform. The portal is the interface for all internal services of the platform.

Furthermore, the platform will be a means by which the developer community will utilize internal and external services as well as promote new services for the portal. It is worth emphasizing that an external service can utilize other external services, not just internal services. However, developers of external services will be responsible for providing an interface to use their services. They can do this through external pages or through applications for other devices.

In the development of the project we adopted techniques closely related to the concept of SOA, which by definition does not restrict developers to adopt languages or development technologies. Therefore, there are developers working on different languages and adopting different development techniques which will be integrated by using the services layer (Enterprise Service Buss). To ensure the availability of the platform services so as not to compromise other services that depend on them, versioning techniques that will enable version control and possible re-application of earlier versions services will be adopted.

3.2 CMPaaS today

Currently, *CMPaaS* project is in development. As its architecture is based on standard SOA, the development of the various services it comprises takes place in parallel by different teams composed of graduate students under

the supervision of researchers. Table 2 shows the services that are in the design phase of development, conclusion or testing.

It is worth mentioning that Table 2 presents only the services that are the result of work and research that are currently in progress. We envision the integration of several computational solutions already developed from previous research. Moreover, because of their extensible nature, we believe that many new services can be thought of, developed and incorporated into *CMPaaS* later.

Services of *CMPaaS*				
Service	**Project**	**Developing**	**Conclusion**	**Tests**
User authentication	X	X	X	X
Map persistence	X	X	X	X
Image generate	X	X	X	X
Transformation (Map to Persistence Model)	X	X	X	X
List of persisted maps	X	X	X	X
Maps merging	X	X	X	X
Proposition extraction	X	X	X	X
ESB integration	X	X		
Text to map service	X	X		
Intelligent engine for inference	X	X		
Query on maps	X	X		
Search for maps	X			
Auto layout generation	X			
Map validation	X			
Maps versioning	X			
Maps comparison	X			

Table 2: *CMPaaS* development status.

As the internal platform services require visual tools for exploitation by end users, the portal of knowledge and its tools are being developed in parallel to the development of *CMPaaS*. Table 3 presents the tools and activities that are already in development for the portal. Again, as the ongoing research advances and new services are added to the *CMPaaS*, the knowledge portal will be equipped with new tools that will be made available to the end-user community.

Tool and Activities of Knowledge Portal				
Tool / Activit	**Project**	**Developing**	**Conclusion**	**Tests**
Concept maps editor	X	X	X	X
Tool for merging maps	X	X	X	X
Maps manipulation page	X	X	X	
Text editor for automatic map generation	X	X		
Visual identity	X			
Portal page layout	X			

Table 3: Knowledge Portal development status.

4 Conclusions

Concept maps have interesting applications in various segments of society. However, many of their possible implementation approaches are avoided due to lack of tools apparatus to assist in the elicitation, organization, analysis and evaluation of the maps. We realize that many existing approaches involve the use of a heavy load of cognitive processing by the teacher or expert to analyze one or more maps generated by a group. We also see that the difficulty in developing specific solutions for automated processing and analysis of concept maps lies mostly in the fact that extensible platform services do not exist, through which developers can create their solutions without worrying about the basic services needed for their applications to be complete, such as the management of user accounts, manipulation and editing of concept maps etc.

This article aims to present the *CMPaaS*, a service-oriented platform whose goal is to provide the community in general, in addition to basic services, management and manipulation of concept maps, as well as more advanced services for analysis, statistical processing and evaluation of same. *CMPaaS* also allows these services to be extended and new services might be generated and integrated, significantly expanding the applications for the various approaches in the use of concept maps.

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