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# Integration of Brainstorming Platform in a System of Information Systems

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## ABSTRACT

Brainstorming digital platforms are Information Systems that take place in the Digital Ecosystem (DE) of Organizations. They are emerged from the organizations need to overcome technical limitations when running brainstorming sessions with experts groups. Additionally, System of Information Systems (SoIS) are special type of System of Systems (SoS) that links together several Information Systems producing overwhelming amount of information to achieve an added value for organizations. In this paper we aim to study the integration of brainstorming platform in a System of Information Systems (SoIS). We propose a model for the brainstorming platform and an architectural model of SoIS that will help in creating the first prototype and facilitate the process of integrating the brainstorming platform in the orchestration of the SoIS. This will pose a significant technical improvement in terms of information interoperability that overcomes conceptual and technical barriers. In this paper we are moving towards a complex Digital Ecosystem (DE) by modeling and developing a prototype that allows the integration of brainstorming platform in a System of Information Systems (SoIS).

## CCS Concepts

•Information systems → Collaborative and social computing systems and tools; *Enterprise information sys-*

*tems*; Wrappers (data mining); •Human-centered computing → Collaborative and social computing; •Computer systems organization → Architectures;

## Keywords

Brainstorming Platform, Digital Ecosystem, System of Systems, System of Information Systems

## 1. INTRODUCTION

Recently, many organizations are directing attention towards harnessing the maximum value from the available information they can access. Other than that, there are some information that resides within the organization but remains out of reach. This information exists in the form of accumulated experience of experts in the organizations. As a solution, organizations tend to hold brainstorming sessions for experts groups to articulate about certain subjects of interest and exchange information. In order to overcome the technical limitations of brainstorming session, the experts groups are provided with digital platform to facilitate information exchange and representation. On the other hand, one of the most important aspects concerning Information Systems in organizations is the way to manage the knowledge produced from those systems. This issue becomes more significant when dealing with complex Information Systems that work in the digital environment forming the Digital Ecosystem (DE) of modern organizations. As organizations attempts to move forward in this complex Digital Ecosystem, they need to apply out-of-the-box ideas to complex systems such as System of Information Systems (SoIS). This raises the concerns about the development process of SoIS. We need to consider the obstacles and concerns of the collaborative SoIS up front. The SoIS needs to connect to Information Systems that cross organizational boundaries, come from multiple disciplines, and generates an overwhelming

amount of resources [12].

Experts deal with many Information Systems in order to exchange their ideas and expertise, one of these systems is the brainstorming platform dedicated to archive and visualize information related solely to brainstorming sessions. Other information might be found in a wiki system used by the experts, in an email system, or even in social media networks. The objective of the collaborative SoIS is to overcome barriers of system interoperability. It should index different resources coming from different Information Systems based on a shared terminology that will facilitate the archiving, filtering, and retrieving of correlated heterogeneous resources.

This paper is organized as follows: section 2 presents the social and technical context of this research. In section 3, the model of brainstorming digital platform, then, the prototype of the platform are presented. In section 4, the model and the prototype of the collaborative SoIS are presented. After that, in section 5, a discussion of the prospective ideas and features of the collaborative SoIS takes place. Finally, this paper is concluded in section 6.

## 2. RESEARCH CONTEXT

In this section we explore the social and technical context of our research.

### 2.1 Social Context

There is a growing need not only to use Information Systems, but also to integrate them with other systems that can benefit from the information generated and shared within a complex Digital Ecosystem. Furthermore, resources provided by different systems can have positive impact on the use of Information Systems.

The word ecosystem was commonly used term in the managerial discourse to describe complex environments with actors collaborating on innovative projects. In the literature, the term appears in the biology introduced by [15] and expresses a balance between different biological species that interact and compete for survival (biota) in an inorganic environment which is common (biotope). The term was transferred to strategy domain to provide a better understanding of grouping trades around a central object [9]. It was used to illustrate an economical model, as the business ecosystems introduced by [13] and [14]. The metaphor illustrates professional or sectoral networks and communities gathered around resources, technologies, platforms involving a leading firm (or central firm), the ecosystem is producing an added value for participants. Digital business Ecosystems or DBE [8] try to define the concept applied to a virtual space constituted by heterogeneous numerical devices. In these versions ecosystems include an environment in which stakeholders from multiple organizations will be encouraged to collaborate on various projects including a creative or innovative dimension.

As an Information System that encourages collaboration on projects with innovative dimension, the brainstorming platform is based on a case study taken from a project run at the French Observatoire des Sciences et des Techniques (OST), a French agency in charge of developing expertise and projects in relation with scientometrics methods. Be-

tween 2012 and 2014, OST has run a project aiming at the development of new methods for the elaboration of thematic multi-disciplinary nomenclatures adapted to the appraisal of scientific production (journals, proceedings), on basis of Thomson Reuters' structured databases (Web of Science). Three thematic expert groups gathered scientists from related research fields, and from different organizations, in order to work respectively about ITs, Energy, and Materials. Our research elaborates on the return of experience accumulated after running the three expert groups.

The groups met on a regular basis during the project in order to reach a consensus with respect to the composition of the nomenclature, to the clusterisation of the journals and documents, and to the relevance of subsequent scientometric indicators for the purpose of S&T policy evaluation. Experts were aware about the threefold outcome of their activity. The expert groups have provided the opportunity for weak ties between experts to emerge in each field, and for relevant knowledge to be created. Experts never had any access to raw data present in Thomson Reuters databases. OST staff (present at the meetings with the experts) worked with the data and developed statistical calculations. The ECOPACK project uses part of the empirical data gathered in the OST project and runs specific field research with the facilitators of the OST expert groups.

Such meetings always proved to be effective for the debates. With time passing by, experts were able to contribute remotely to the (synchronous) meetings and preserve the same level of effectiveness in the debates. One main issue however impacted the project: the availability of the experts, and the subsequent difficulty at organizing meetings. The installation of a collaborative system suited to easier interactions partly justifies the ECOPACK project.

### 2.2 Technical Context

This research takes into account the heterogeneous resources, which are shared by collaborators on different Information Systems, which could improve the understanding of their field of expertise [7]. According to [7] the solution to the problem of experts identification or research within heterogeneous information of an organization can be reached through the concept of Knowledge Ecosystem (KE). This concept comes directly from Digital Ecosystem (DE) [2]. This theory is based on the idea that innovation and learning new skills will be drastically improved in an environment, which favors primarily human interaction and especially the self-learning in a self-organized structure. This approach is opposed to the more traditional view of a top-down education. To take this work further we need a solution that allows us to preserve the autonomous nature of different Information Systems operating within the organization, and still be able to archive, access, track and analyze the resources produced from those systems with the help of a knowledge base. The aim is to move towards a System of Information Systems (SoIS) to manage heterogeneous information coming from different Information Systems and control the process of sharing information with simplicity and ease.

The notion of System of Information Systems is defined by [4] as "Networks of agents interacting in a specific technology area under a particular institutional infrastructure for

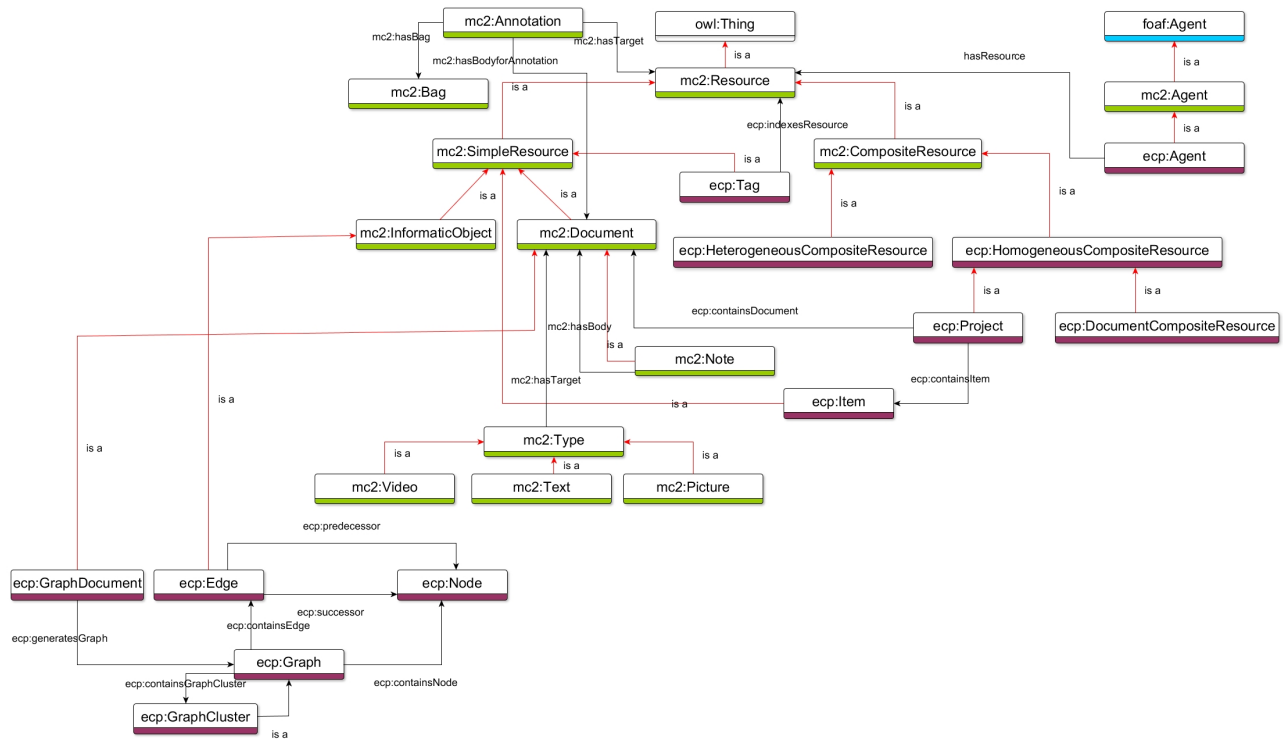


Figure 1: ECOPACK Brainstorming Digital Platform Model

the purpose of creating, diffusing, and utilizing technology focused on knowledge and information.” [3] describe SoIS as “the specific clusters of the firms, technologies, and industries involved in the generation and diffusion of new technologies and in the knowledge flow that takes place among them.”

According to [11], no matter how complex or geographically distributed, the system at study should be called a System of System (SoS) only when it fulfill both of the following:

- Operational Independence of the Components: If the SoS is disassembled into its component systems the component systems must be able to usefully operate independently. That is, the components fulfill customer-operator purposes on their own.
- Managerial Independence of the Components: The component systems not only can operate independently, they do operate independently. The component systems are separately acquired and integrated but maintain a continuing operational existence independent of the SoS.

An approach to SoS information interoperability is presented in [5] based on two emerging trends, Dataspace and Linked Data. A Dataspace is a conceptual approach to information management that supports the co-existence of heterogeneous data with an incremental approach to interoperability. Linked data is a technology that leverages the web architecture to share data in a flexible and incremental manner to reduce technological barriers. When used together the

resulting Linked Dataspace can provide a viable approach to SoS information interoperability.

### 3. ECOPACK BRAINSTORMING PLATFORM

#### 3.1 Model

In order to develop the ECOPACK brainstorming platform we need to follow a well-structured model that meets the needs of the platform and represents its concepts. In the first place, the resources in the platform are considered to be either simple or composite resources. Simple resources are basically a single document or an informatics object. Since the platform will depend on visual representation of data as graphs, those graphs are also composed of simple resources, informatics objects to be precise, in the sense of edges and nodes. On the other hand, composite resources describe more structurally complex resources such as projects composed of different homogeneous items. Furthermore, there is also a need to model the annotation, notes, and other editorial forms. The following list represents the ideas and features that should be shown by the model:

- The availability of projects composed of digital items.
- The types of digital items are representable as images, PDF documents, data organized in the graph.
- Comments on project or data levels.
- The graphic data of a project can be represented in several different forms. The graph nodes can be retrieved from text criteria to show the spanning tree of the graph. Screenshots of the project can be archived.

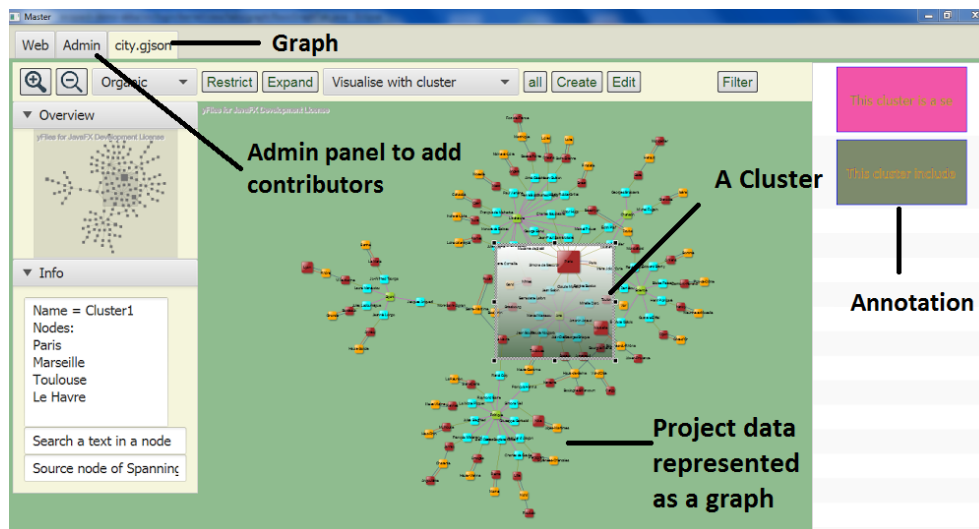


Figure 2: The main module of the ECOPACK brainstorming platform.

- The reporting of a brainstorming session, the comments, and screenshots are embedded in a PDF document.

Taking a look at the ideas that should be present in the model of the brainstorming digital platform will allow the use of a model for knowledge management called MEMORAE-core 2. So, what is MEMORAE-core 2? the idea started as the MEMORAE-core 2 approach for knowledge management then the approach has led to the development of MEMORAE-core 2 model and then MEMORAE-core 2 platform. The MEMORAE-core 2 model employs the Semantic Web standards. All the users of MEMORAE-core 2 are given access to several knowledge bases. When a knowledge base is selected, a user can view a semantic map of concepts related to the chosen base. Then, a user can create and share resources around the concepts of the map. The main contribution of this approach is to allow the indexing of all types of resources around a semantic map of shared terminology in the organization environment. However, this solution is tied down to integrate different types of resources like wikis, forums, or shared calendars inside MEMORAE-core 2.

The resources in MEMORAE-core 2 are divided into two main categories: simple and complex. A document, an agent, a note can be direct examples of simple resources. Complex resources are composed of other resources (e.g: a note cluster is composed of one or more notes). Each resource is indexed by an index key which is visible for a certain sharing space. The model supports documentary resources and social resources (e.g., chat, forum, wiki).

MEMORAE-core 2 model uses the following semantic web standards:

- SIOC (Semantically-Interlinked Online Communities): It aims to enable the integration of online community information.
- FOAF (Friend Of A Friend): It describes persons, their activities and their relations to other people and objects.

- BIBO (Bibliographic): It describes the bibliographic resources.

In this section we move forward from MEMORAE-core 2 model towards a model for ECOPACK Brainstorming platform. It is useful to take into account the standard representation of resources in MEMORAE-core 2 and build upon it the representation of resources used in ECOPACK. The prefix ?mc2? refers to a concept coming from the MEMORAE-core 2 model, while the prefix ?eco? represents a concept specific to the ECOPACK Brainstorming platform.

### 3.2 Prototype

In this section we introduce a prototype developed based on the model presented earlier. The brainstorming digital platform is developed on the premises of a Digital Ecosystem capable of meeting the needs of innovation and strategic analysis of experts groups. The approach of this digital platform follows the knowledge ecosystem vision that promotes the dynamic evolution of knowledge interactions between users in order to improve decision making and innovation. The technical objectives of the ECOPACK brainstorming platform are as follows:

- Define a multi-user computer platform incorporating several types of devices (tablets, smartphones, PCs) for different forms of collaboration.
- Define collaborative applications accessed from different devices. Each user will benefit from different types of interaction and activity and will be able to exploit his/her own resources to collaborate. Applications developed can be synchronous, asynchronous, co-located and/or remote.

ECOPACK brainstorming platform is a set of heterogeneous data grouped as items, presented and gathered by a main module. The main module is responsible for providing a dynamic representation of the data as a graph that allows the interpretation by experts. It is essential to differentiate between the graph in the ECOPACK platform and the map in MEMORAE-core 2. The graph in the first one is merely a

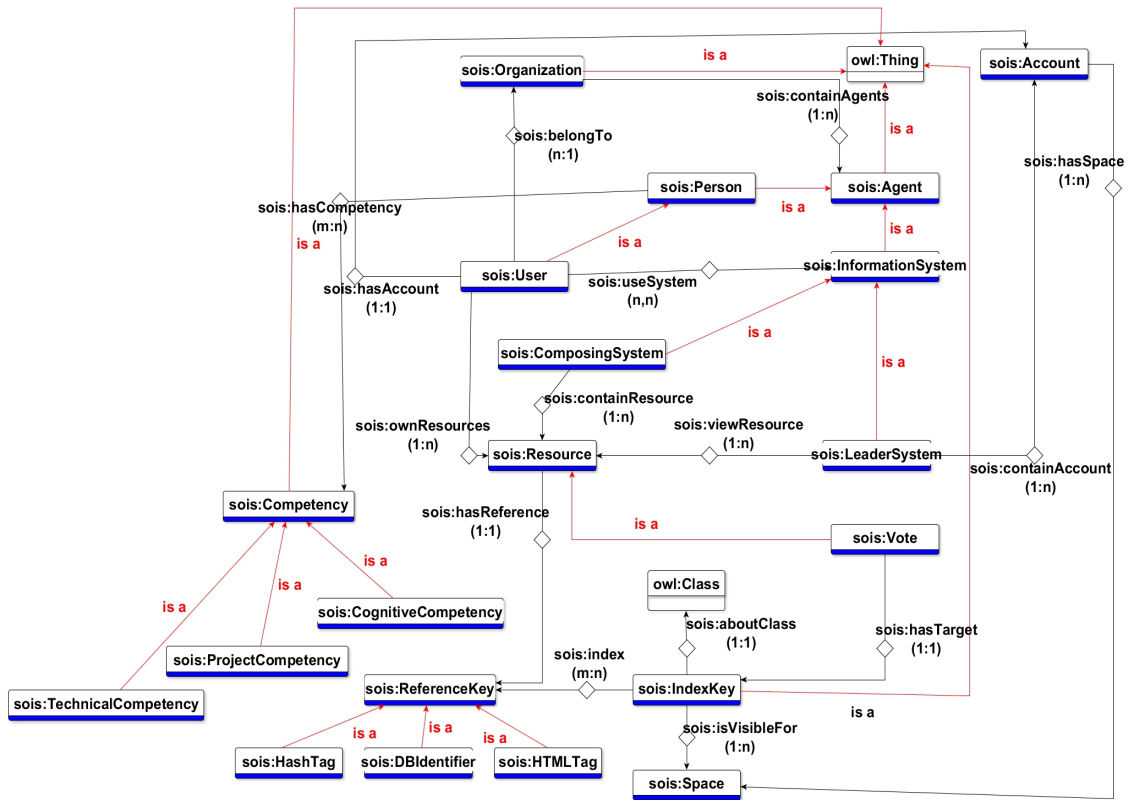


Figure 3: Semantic model of the collaborative SoIS.

product of a visualization tool to represent data under discussion for brainstorming sessions, while in the latter, the map represent shared terminology among collaborators used to index heterogeneous resources that share the same target. Work is divided into work sessions. Participants in work sessions are permitted to send comments on the displayed data by the additional modules. The schedule module provides a representation of a small area of information visible on the main module. (Fig. 2) shows the main module of the ECO-PACK brainstorming platform.

The platform is designed and equipped with different features for the benefit of experts working together in a brainstorming session. The main module provides several tools to enhance participants experience when working with graph data. The graph can be shown in different ways following different styles and hierarchies. Also, there is the ability to zoom in and out with the graph. In addition, the main module provide the possibility to create clusters within the graph. Clusters can be modified, and nodes can be added or removed from clusters. Cluster view also can be toggled on or off to show the graph with or without clusters based on the course of discussion taking place. In relation to comments and annotations, participants can create notes related to certain aspect of the graph shown in the main module. The creation of the note is handled by a separate dedicated application that reside within the participant’s device. The note is then sent to the main module to be shown in the graph for everyone to see and discuss. Furthermore, the note can target the graph as a whole, or a specific part of

the graph. It also can target a node or an edge, or even a group of nodes and edges combined together as a cluster. Another feature is the dashboard of experts’ activities with the platform. This is useful to give a precise statistical information of experts’ contributions.

## 4. COLLABORATIVE SYSTEM OF INFORMATION SYSTEMS

### 4.1 Model and Architecture

This section presents a semantic model of the collaborative SoIS built using owl (Web Ontology Language) and based on semantic web standards. The model is present in (Fig. 3). The model highlights the position of an agent, either as an Information System or as a user, in the orchestration of the SoIS. The model also shows how resources are created by users and contained in the composing systems of the collaborative SoIS, while the leader system is only showing those resources through a reference key. Each resource has a reference which functions as a link between the resource and the leader system. This key can be an HTML tag, a Database Identifier, or social bookmark as a Hash tag. Following the MEMORAe approach, the leader can view a semantic map of shared terminology in the work environment. The semantic map allows the indexing of references to the actual resources through the index key and sharing it within different sharing spaces.

The architecture of the collaborative SoIS is shown in (Fig. 4). As seen in (Fig. 4), the collaborative SoIS will ag-

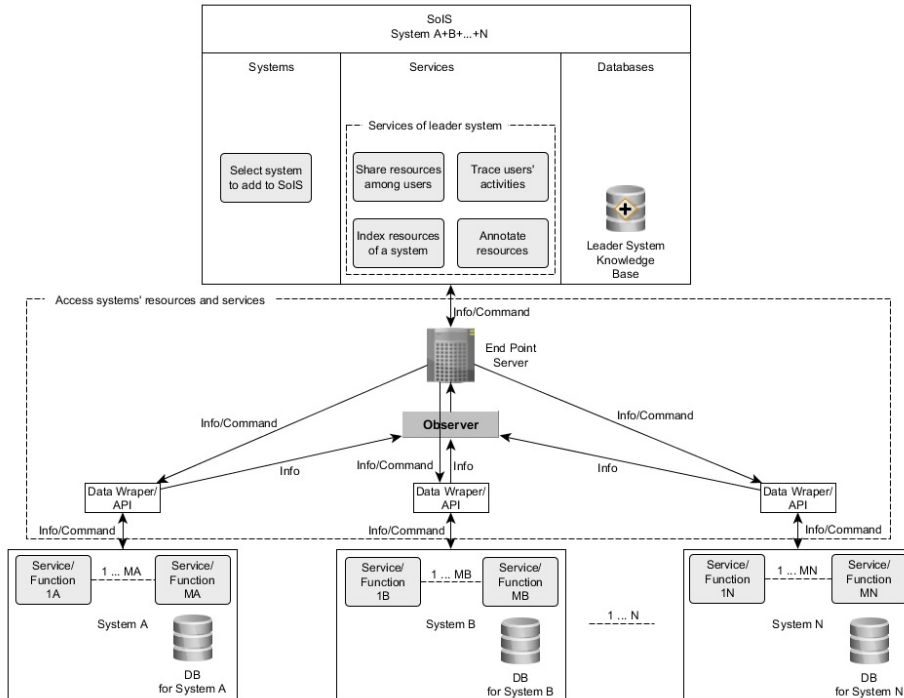


Figure 4: Architectural model of the collaborative SoIS.

gregate heterogeneous information and resources from different Information Systems (System A, System B ?etc.). These systems are autonomous and work separately of each other. Each of which has its own services/functions and databases. The services/functions of these systems are denoted inside the system (Service/Function 1A, Service/Function 1B ?etc.). The architectural model here differentiates between services and functions. While some systems are openly providing an API for requesting their services, other systems are closed and operate as black boxes to the outer world and only provide functions invoked within the system itself. Information can be represented in different ways within different systems, thus, the collaborative SoIS might face some troubles accessing information, unless the services of that system are available through an API.

## 4.2 Prototype

In this section we propose a prototype developed based on the architectural model presented earlier. Other than the leader system, which is MEMORAE system as discussed earlier, the prototype links to two separate Information Systems. These systems are TiddlyWiki and a brainstorming digital platform.

Technically, a TiddlyWiki is purely an HTML document with a rather large JavaScript section that takes care of displaying all of its contents. The javascript is also responsible for providing the interactive tools for content manipulation. The actual content of the document is not always visible for the user. It is stored in a set of invisible DIV elements, called ?tiddlers?. The content of the DIV elements forms wiki text, i.e. text with a simple markup language. When the user clicks on a tiddler name to show its content, the

JavaScript renders and translates the wiki text into HTML to view it for the user. Special fragments can be included in the text to trigger the actions of sub procedures. In addition, some tiddlers are interpreted as a stylesheet or a JavaScript plugin. To edit a tiddler, it is replaced inline by a form, and the user is presented with the original text ready to be edited and saved again [1].

The community members participating in a brainstorming session may have several platforms with dedicated purposes to work with like social networks or wiki systems. Therefore, they might lack a comprehensive view of all resources produced, exchanged and shared within those dedicated systems. For a given subject, they are forced to query each platform to extract the relevant resources. The solution provided by the collaborative SoIS prototype serves as a Digital Ecosystem with a shared repository of a knowledge base.

All the users of the collaborative SoIS are able to access their heterogeneous resources, mostly wiki pages entries and brainstorming projects, from the collaborative SoIS as seen in (Fig. 5). In this figure we can see two boxes used to access TiddlyWiki System and ECOPACK brainstorming platform. Moreover, there is a button with a “plus” sign. This button will allow the user to navigate through all the resources available in the dedicated Information System and select from the list of resources which are going to be indexed by the semantic map and shared in certain sharing spaces. It also allows the user to create new resources in their respected Information System. The panel to navigate through resources or create new ones is shown in (Fig. 6). The resources of the dedicated Information System is made available to the user by means of the data wrapper and



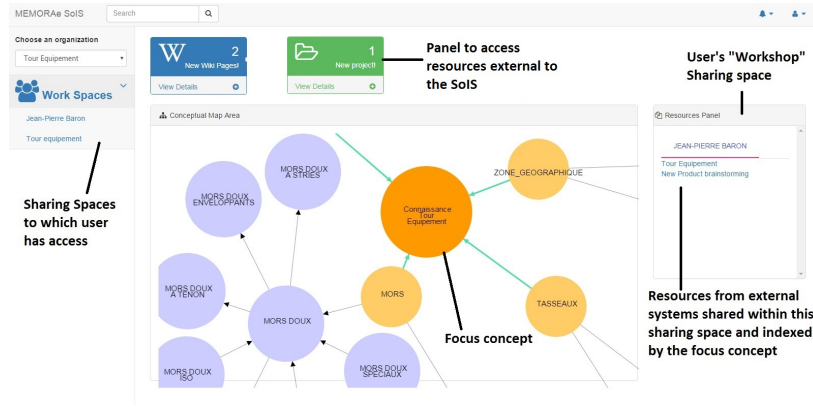


Figure 5: Collaborative SoIS with TiddlyWiki and ECOPACK brainstorming platform.

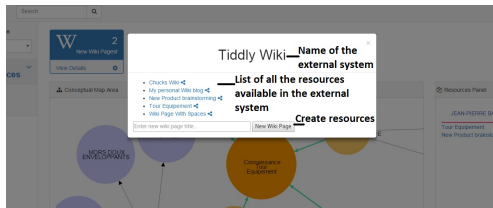


Figure 6: Panel to access resources available in the Information System, or create new ones.

the server/observer endpoint shown in the architecture in (Fig. 4).

### 4.3 Validation

The SoIS resulting from this study needs to be validated in a real life scenario to insure the integrity of the platform and hence the architecture. According to [6], Information System success is a multidimensional and interdependent construct and it is therefore necessary to study the interrelationships among, or to control for, those dimensions. Also, the success model needs further development and validation before it could serve as a basis for the selection of appropriate Information System measures. Thus, in the forthcoming steps, this study will take into consideration the following points to test the validity of the SoIS:

- Information quality will positively affect the use of SoIS.
- Information quality will positively affect user satisfaction.
- The quality of Information Systems composing the SoIS will positively affect the use of SoIS.
- The quality of Information Systems composing the SoIS quality will positively affect user satisfaction.
- Service quality will positively affect the use of SoIS.
- Service quality will positively affect user satisfaction.

For these points to be tested we plan to collect feedback data from students at the University of Technology of Compiègne to evaluate the preference of the SoIS. The students

are enrolled in a Knowledge Management course. We will use their feedback on the SoIS based on two aspects; a survey form, and hands-on sessions with the SoIS. As mentioned in the discourse of this study, the added value of the SoIS is to provide users' activities traces over heterogeneous resources. We will analyze the traces of the students as they work with the SoIS. The results will provide us with the information needed to validate the SoIS and its architecture in a real life scenario.

## 5. DISCUSSION

This section elaborates on the topic of information flow between the leader system of the collaborative SoIS and its member Information Systems. In the prototype presented earlier of the collaborative SoIS information flow from the member Information System to the leader system as references of resources only. The leader system does not have a global view on the information of its member systems. For the moment, it only need a reference of the resources residing in the member system to index it based on a map of shared terminology. It would be a good practice to discuss the possibility having a global view of the member systems within the leader system of the collaborative SoIS. This, however, will increase liability over the observer server responsible for this kind of communication. But still, there will be more information available to be present in the dashboard of users' activities in the collaborative SoIS. After all, the added value of the presented collaborative SoIS is the ability to trace user activities around resources indexed in a map of shared terminology. This will provide guidance on the competency levels of different users regarding various projects and/or subjects.

The work in [10] presents a Communicating Structures Library (CSL) for SoS. The Communicating Structure is a hierarchical and concurrent structure that represents the SoS components and communication between them. The system components are represented simply as nodes. The nodes have memory that may contain items. Nets are sets of links that connect the nodes. The items are generated in some nodes and move from node to node along links concurrently and with some delay. Although this study shows promising results regarding performance enhancement in a complex structure like SoS, from our point of view, it fails to address the autonomous nature of the SoS. The data can flow



from node to node, which mean from system to system. In that case the member systems of SoS loses their autonomous nature as they depend on external data to function. Nevertheless, this Communication Structure can be utilized in our collaborative SoIS to remodel the communication medium in our architecture for better performance.

## 6. CONCLUSION

The goal of this paper was the integration of brainstorming platform in a System of Information Systems. This helps in managing heterogeneous information in the SoIS obtained from different users working with several Information Systems in the digital environment of organizations with simplicity and ease. The aim was focused towards investigating the role the collaborative SoIS in facilitating resources management for experts groups participating in brainstorming sessions, by providing a semantic model of SoIS to guide the migration for such complex system. To achieve this goal this paper undertakes an effort to present the social and technical context of this research and define the state of the art, then move to present the model and the prototype of the ECO-PACK brainstorming platform, then the semantic model of a collaborative SoIS. This paper found potentials in deploying MEMORAe approach to manage the resources produced by different systems in the collaborative SoIS. It was also clear that combining resources from various Information Systems and manage them within a map of shared terminology will result in an added value to users not present when those systems were operating separately. The most important value for the collaborative SoIS is in its ability to trace users' activities. Furthermore, the collaborative SoIS can upgrade this value by providing analysis of these activities to determine users' competence levels at certain subjects or importance level of concepts.

The next step is to expand our work and introduce new Information Systems to the SoIS based on the first prototype presented in this study and users' needs. The collaborative SoIS should keep simple interface, with all the correlated resources as far from the user as a single click, to keep the users experience useful and friendly.

## 7. REFERENCES

- [1] F. Bagnoli, P. Jipsen, and A. Sterbini. Tiddlywiki in science education, 2006.
- [2] D. Bray. Knowledge ecosystems. In *Organizational dynamics of technology-based innovation: Diversifying the research agenda*, pages 457–462. Springer, 2007.
- [3] S. Breschi and F. Malerba. *Sectoral innovation systems: technological regimes, Schumpeterian dynamics and spatial boundaries*. Centro studi sui processi di internazionalizzazione, Università commerciale'Luigi Bocconi', 1996.
- [4] B. Carlsson and R. Stankiewicz. On the nature, function and composition of technological systems. *Journal of evolutionary economics*, 1(2):93–118, 1991.
- [5] E. Curry. System of systems information interoperability using a linked dataspace. In *System of Systems Engineering (SoSE), 2012 7th International Conference on*, pages 101–106. IEEE, 2012.
- [6] W. H. Delone and E. R. McLean. The delone and mclean model of information systems success: a ten-year update. *Journal of management information systems*, 19(4):9–30, 2003.
- [7] E. Deparis, M.-H. Abel, G. Lortal, and J. Mattioli. Information management from social and documentary sources in organizations. *Computers in Human Behavior*, 30:753–759, 2014.
- [8] P. Dini, M. Darking, N. Rathbone, M. Vidal, P. Hernandez, P. Ferronato, G. Briscoe, and S. Hendryx. The digital ecosystem research vision: 2010 and beyond. position paper following the cycle of workshops 2005 and the online debate, july 2005, bruxelles, 2005.
- [9] G. Gueguen and J. Passebois-Ducros. Les écosystèmes d'affaires: entre communauté et réseau. *Management & Avenir*, (6):131–156, 2011.
- [10] V. Kotov. *Systems of systems as communicating structures*. Hewlett Packard Laboratories, 1997.
- [11] M. W. Maier. Architecting principles for systems-of-systems. In *INCOSE International Symposium*, volume 6, pages 565–573. Wiley Online Library, 1996.
- [12] S. Majd, A. Marie-Hélène, and M. Alok. An architectural model for system of information systems. In *On the Move to Meaningful Internet Systems: OTM 2015 Workshops*, pages 411–420. Springer, 2015.
- [13] J. F. Moore. *The death of competition: leadership and strategy in the age of business ecosystems*. HarperCollins Publishers, 1996.
- [14] J. F. Moore. Business ecosystems and the view from the firm. *Antitrust Bull.*, 51:31, 2006.
- [15] A. G. Tansley. The use and abuse of vegetational concepts and terms. *Ecology*, 16(3):284–307, 1935.