Searching for Weak Signals in the Web to Support Scenarios Building for Future Studies

Rodrigo Teixeira dos Santos[1][a], Edilson Ferneda[1][b], Hercules Antonio do Prado[1][c], Aluizio Haendchen Filho[2][d], Ana Paula Bernardi da Silva[1][e], Roseane Salvio[3][f] and Elaine Coutinho Marcial[4][g]

[1]*Catholic University of Brasilia, Brasilia-DF, Brazil*

[2]*University of the Itajai Valley, Itajai-SC, Brazil*

[3]*Federal Institute of Brasília, Brasilia-DF, Brazil*

[4]*Mackenzie Presbyterian College of Brasilia, Brasilia-DF, Brazil*

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Abstract: A specification of a multi-agent system for searching weak signals on Internet is proposed for supporting future studies. A set of software artifacts are presented, including: *(i)* functional/non-functional requirements; *(ii)* use-cases involving human and software agents; *(iii)* a database model containing the main entities; and *(iv)* a role and functional model with the main interactions and activities the agents are involved. A prototype were developed and evaluated by experts in future studies. From this specification/prototype, an early warning system can be developed to support intelligence analysts in producing qualified information for future studies.

1 INTRODUCTION

Concerns on future have always been on human race focus. It is probably more intense in the current days due to the accelerated rhythm of change and the increasing uncertainty as consequence of the downfall of the well-regulated world (Jouvenel, 2000). Along the ages, the fear had been an important mechanism for mind changing of the human being, leading to the acknowledgment that the future is not pre-determined or written, but rather can be built by the actions of social actors. In this way, people had to learn how to live under uncertainties, observing that the future emerges from seeds (or signals) left in the past or present (Marcial and Grumbach, 2002). These seeds must be captured and assessed for building knowledge about the future as done in the disciplines Strategic Prospective and Competitive Intelligence (CI).

Scenarios Building is a tool for studying the future. It helps to give a long-term approach in a world of uncertainties (Schwartz, 1991). Moreover, it stimulates strategic thinking and helps to run over thinking limitations by means of multiple futures envisioning (Ammer, Daim, and Jetter, 2013).

Godet and Roubelat (1996) argues that "multiple and several potential futures are possible; the path leading to this or that future is not necessarily unique. The description of a potential future and of the progression towards it comprises a *scenario*".

For Marcial and Grumbach (2002), Scenarios Building is an important tool for generating and assessing strategic definitions in the increasingly turbulent and uncertain environment we live in. Moreover, it facilitates the communication concerning visions about the future, unifying organizational language, helping the creativity development, and the organizational learning. It also

[a] https://orcid.org/0000-0002-2138-8126
[b] https://orcid.org/0000-0003-4164-5828
[c] https://orcid.org/0000-0002-8375-0899
[d] https://orcid.org/0000-0002-7998-8474
[e] https://orcid.org/0000-0002-9963-282X
[f] https://orcid.org/0000-0001-9172-8299
[g] https://orcid.org/0000-0001-9686-8418

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improves the understanding on the organizational surroundings, allowing to envision the possible risk situations and uncertainties.

Scenarios Building can be considered under two complimentary approaches (Godet, 1986): *(i)* exploratory, the ones that highlights actual or past trends and that may draw a possible future; and *(ii)* normative/anticipative, that takes the opposite route, starting from the future to the present, thereby inducing the factors of evolution.

An important kind of information for scenarios planning is the weak signals, defined by Ansoff (1982) as “external or internal warnings that are too incomplete to allow in precision their impacts or an estimate response to them”.

The connection between the Scenarios Building Method and the analysis of weak signals can occur in the context of an intelligence activity. It involves production of information integrated, assessed, with high aggregate value, and in the most part, carrying seeds of future (Marcial and Grumbach, 2002). For short, Scenarios Building Method relates to CI in the sense that the former produces future views and the path that leads to them, and the latter helps with the production of pieces of possible information.

Additionally, Prescott (1995) states that CI is more than a product, it is a process that helps the organization in the anticipation of threats and opportunities, in order to take decisions in a securer way and make your competitive environment better monitored. The use of CI is endorsed by the aggregated business value in the endeavor, pursuing a competitive advantage. CI is a legal and ethical process of collection and informational evaluation regarding the competitors and industries in operation to help an organization in taking better decisions and reach its goals (Bergeron and Hiller, 2002).

Marcial and Grumbach (2002) recognize the connection between CI with scenarios building and strongly recommends its application to keep tracking of actors or variables that might be important to achieve organizational objectives.

The widespread of mobile devices and social networks in the last years enabled the creation and transmission of digital contents in astonishing levels. This huge amount of information has made hard the companies to identify weak signals. In this paper, an approach for identifying and monitoring this kind of information in Internet is proposed.

2 BACKGROUND

2.1 Weak Signals

A signal is an event in which any actor in the environment sends a message while executing an activity or as a result of a specific action (Coffman, 1997). When a message is sent, someone or something may receive and understand it. There are three types of signal (Coffman, 1997): *(i)* the ones beyond perception; *(ii)* the perceptible, but unknown due of the receptor’s mindset; *(iii)* those that are known by the receiver’s and are used for a behavior change. The first ones are just signals that are continuously sent by the source, but not received. The second ones are perceptible by the receiver but for some reason they are ignored. The third signals type are those signals that are perceived by the receiver and is used to adjust its own course, actions or behaviors.

In a philosophical sense, Jouvenel (2000) says that “the future leaves in the past and in the present, seeds that might germinate or not […] transforming into great fruit trees, plants that will never bear fruits or weeds”. One of these seeds is those facts that carriers the future and are characterized by being apparently unimportant, but with relevant consequences and potentialities. These are the weak signals.

One of the main objectives when dealing with weak signals, is to take awareness of the organization surrounding, allowing it to keep an advantageous position with respect to its competitors (Janissek-Muniz and Blanck, 2014). Furthermore, these situations lead to perceptions of possible future situations that might be interesting for the organizational evolution (Marcial and Grumbach, 2002). Being aware of these signals may drive the organization to possible different futures like an innovation or a trend that affects business and its environment (Coffman, 1997). It includes threats or opportunities, learning lessons, growing, and developing.

In order to search for weak signals for envisioning the future, it is important to consider that these pieces of information are "anticipative, qualitative, ambiguous, fragmented and may come in various formats and from distinct sources” (Fonseca and Barreto, 2012). Additionally, Marcial and Grumbach (2002) emphasize the importance of perceiving the mindset involved in the signal signification process.

A process for searching anticipative signals were proposed by Fonseca and Barreto (2012) and comprises the following steps: *(i)* stimulus perception; *(ii)* interpretation for sense making of the identified signals; *(iii)* learning or incorporation of a new information in a company database. The importance of this process for an organization is highlighted by Freitas and Janissek-Muniz (2006) for generating warnings when some key intelligent topic is modified. During the process, some questions must be answered: What information has been searched? What type of information has been searched? Whom is concerned about the information? What is the information source? How it was obtained? Why is the information important? What is the objective of the information?

With respect to the sources of weak signals, Marcial and Grumbach (2002) considers two possibilities: formal sources, that involve books, reports, laws, normative papers, patents, Internet, among others, and the informal, that include interactions with competitors, clients or providers, and participation in congress or seminars.

2.2 Early Warning Systems and Search on Internet

The interest on Early Warning Systems (EWS) emerged in the sixties as an alternative for international policies change predictions (Rausch et al., 2012). Later, in the seventies, the ability of offering a timely response to a problem began to be considered as an important characteristic of EWS (Ansoff, 1980).

Ansoff (1980) argues that organizations have always faced a paradox when dealing with issues apparently unimportant: usually they wait until the fact is better known to adapt their strategic planning.

Ansoff and McDonnell (1990) proposed the Issue Strategic Management System that deals with unexpected change in three ways: *(i)* Detecting surprises in real time; *(ii)* Responding in the moment that they occur without updating the strategic planning; and *(iii)* Creating a problem solving cross organizational task force.

Dohn et al. (2013) suggest the following requirements when considering the Internet as a context for EWS searching: *(i)* To have a high amount of storage and processing capacity in order to make possible the integration of potentials weak signals; *(ii)* Being flexible enough to make possible changes; *(iii)* Having integrating tools with quantitative and qualitative characteristics; *(iv)* Enable the information sharing with stakeholders interested in the same issue; *(v)* To have usability and portability; *(vi)* To enable the users integration; *(vii)* To define actions from weak signals; and *(viii)* Stimulating the organizational learning.

Due to the textual nature of most information in the Internet, the search for weak signals on there can benefit from text analysis techniques like Text Mining and Natural Language Processing. Mainly considering that the Internet consumes too much time from the users when they need to find some information (Dkaki, Dousset, and Mothe, 1997). Weiss, Indurkhya, Zhang (2010), Meystre et al. (2008) reinforce the advantages of these techniques for solving problems like documental classification or organization, information retrieval or extraction, clustering analysis, assessment, prediction, and named entity recognition.

Other important tool to be considered for searching weak signals in the Internet are the web crawlers. Web crawlers are a kind of robot that cross the web searching for information that might be indexed and retrieved (Kumar, Bhatia, and Rattan, 2017). Figure 1 shows a generic architecture for a web crawler. Web crawling starts from an initial URL and seeks for other links aiming to retrieve the most webpages and web documents related to a topic.

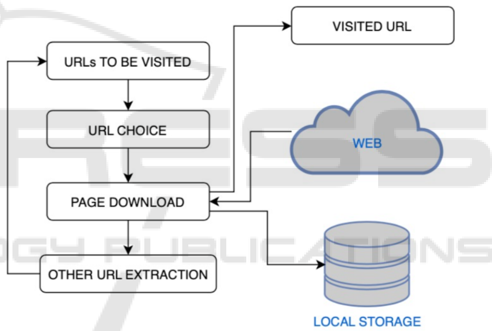

Figure 1: Generic architecture of a web crawler (Kumar, Bhatia, and Rattan, 2017).

3 RELATED WORKS

The literature regarding EWS techniques is related to issues like CI, corporate foresight, decision making, early warning, early detection, environmental scanning, foresight, horizon scanning, scenario, social network, and strategic planning.

Saritas and Burmaoglu (2015) point out that, in the EWS context, the amount of methods, both quantitative and qualitative, is increasing, including the ones applied to foresight practices. In the same sense, Muhlroth and Grottke (2018) notices a strengthening in the research related to EWS and emphasize the importance of investments in improving search engines, releasing human effort for more advanced stages of studies.

Schuh et al. (2016) proposed a generic EWS model, emphasizing that these systems must produce results that allow an organization to take specific actions and learn from them.

Steinecke, Quick, and Mohr (2011) suggested six points to be considered when implementing a EWS system: *(i)* visualizing both, the internal and external, organization environment; (*ii)* the existence of indicators to monitor causes and effects; (*iii)* automatize the indicators management; (*iv)* proceed to a benchmarking of implementations; (*v)* to apply the results found.

Rohrbeck, Thom, and Arnold (2015) argues that an important requirement for a EWS is the ability to integrate information from different people, enable the emergence of knowledge from the confront among ideas and connect this result to a specific organizational process.

For Gheorghiu, Andreescu, and Curaj (2016), an EWS must keep good early signals sources, efficient information filters and a consistent characterization of those signals.

A great variety of techniques for EWS can be found. Garcia-Nunes and Silva (2018) aggregates ontologies for text analysis in order to provide semantic analysis. Kim, Park, and Lee (2016) apply keyword-based analysis for envisioning weak signals. Dousset, Elhaddadi, and Mothe (2011) emphasizes that weak signal orbits near these keywords. Semantic Analysis is also explored by Griol-Barres, Milla, and Millet (2019), combined with quantitative textual analysis, as cooccurrence of terms. This technique is also applied by Kim et al. (2019). Along with web crawlers, text analysis tools are applied for searching on the Internet (Garcia-Nunes and Silva, 2018; Kim et al., 2019).

Schuh et al. (2016) propose a generic model for EWS, emphasizing that such systems must provide qualified information for decision making support, beyond strengthening the organizational learning.

Steinecke, Quick, and Mohr (2011) identified some issues to be considered when implementing an EWS: *(i)* watching internal and external environments; (*ii)* availability of causal indicators; (*iii)* apply Information Technology for managing indicators and the information sources to be monitored; (*iv)* search for complimentary and contextual information for supporting results analysis; (*v)* managing the results; and (*vi)* create procedures able to update systems and share the findings.

Rausch et al. (2012) recommended that this kind of system must comply with the cultural characteristics of each country.

For Dohn et al. (2013), an EWS can support an organization by: (*i)* integrating many methods and concepts for detecting early signals; (*ii)* information management; (*iii)* causal networks interpretation.

In their analysis of an EWS, Rohrbeck, Thom, and Arnold (2015) consider relevant the system cope with information from many people, issuing knowledge from different points of view and enabling the connection of this knowledge with an organizational process.

Gheorghiu, Andreescu, and Curaj, 2016) adds good filtering processes and a categorization of weak signals as requirements for a successful EWS.

4 ANALYSIS AND DESIGN

The previously discussed approaches focus on searching on the Internet for enforcing the soundness of a hypothesis. The proposal here presented is focused in prospection of signals with no prior definition of an inquire but inside a defined interest domain. The proposal design benefits from the low-coupling and flexibility of multi-agent systems (MAS). Under a functional point of view, the choice for MAS technology consider the possibility of having some level of intelligence on the search process. The analysis phase comprises the choose of the development tool and the system requirements specification. The project phase consists in define the functionalities and the generic architecture of the system and the data model.

4.1 Adopted Platform

It was adopted the MIDAS (Haendchen Filho, 2021) framework for the implementation of the prototype. The architecture is based on the coexistence of several containers that communicate by means of a front-end server. Each container provides an environment for development and execution of agents. Figure 2 shows the platform generic architecture.

The framework consists of three layers: *(i) Middleware*, represented by the entities Broker, Proxy, Catalog, Manager, and Blackboard; *(ii) Services*; and *(iii) Agents*. The middleware layer facilitates the development by abstracting complex developer procedures. It provides communication, concurrency, lifecycle management, and discovery. The *Agents* and *Services* layers enables development of microservices agent-based applications.

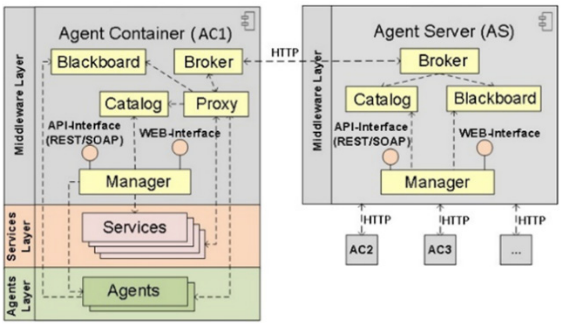

Figure 2: MIDAS Architecture.

The applications are instantiated from the Agent Container (AC_1 ... AC_n). The communication between *Agent* and *Service* layer is done by Proxy. An agent does not need to know who the service provider is. This feature ensures transparency and decoupling from the implementation. Services can be independently created, and agents can use and coordinate these services in their workflow.

The platform uses three interfaces: *(i) HTTP* for inter-platform communication among the front-end server AS and the AC containers; *(ii) API* interface, which enables the communication with external applications via REST protocol; and *(iii) a WEB-Interface* for platform management and configuration by developers and stakeholders.

4.2 Functional Requirements

Nine functional requirements were considered for implementing the solution: *(i) Identifying domains for categorizing* weak signals; *(ii) Automatic search* for crossing the web for finding information (crawlers); *(iii) Keeping pages contents* for later analysis; *(iv) Results analysis*, in order to elaborate knowledge from data stored; *(v) Storing final results,* necessary for persistency of a signal; *(vi) Websites list*, important for defining a start point for a search; *(vii) Storage and structure*, necessary for keeping complimentary information; *(viii) Integration,* to enable interchange of information among the people involved; and *(ix) Access to the tool*, including usability and ability to run on multiplatform. The human actors are: *(i) Standard User*, *(ii) Manager of Studies*, and *(iii) Expert*. The software agents, instantiated from MIDAS, are: *(i) AgLINK*, *(ii) AgWEB*, *(iii) AgRESULT*, and *(iv) AgWORD*.

The most important use cases extracted from the relation among *requirements* and respective *actors* are: *(i) Maintain search domain* (Manager of Studies); *(ii) Visualize my studies* (Manager of Studies); *(iii) Visualize the ongoing studies* (Manager of Studies); *(iv) Login the tool* (Standard User); *(v) Register study* (Manager of Studies); *(vi) Stop study* (Manager of Studies); *(vii) Maintain stopwords* (Manager of Studies / Expert); *(viii) Maintain dictionary* (Manager of Studies / Expert); *(ix) Invite for discussion* (Manager of Studies); *(x) Maintain discussion* (Manager of Studies / Expert); *(xi) Manage signal* (Manager of Studies / Expert); *(xii) Generate word maps* (AgWORD); *(xiii) Maintain preliminary results* (AgRESULT); *(xiv) Maintain Web information* (AgLINK / AgWEB).

4.3 Generic Architecture

Figure 3 shows the main elements of the architectural

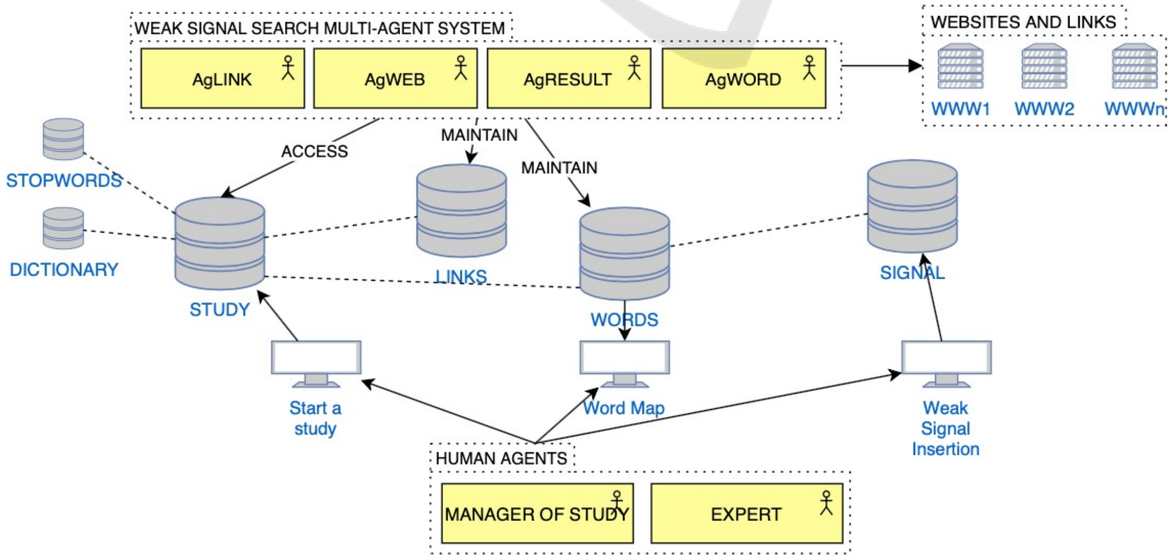

Figure 3: System generic architecture.

model, including the inter-relations among actors. *Standard User* represents people involved in any study, *Manager of Studies* is responsible for keeping track of information on the studies, and *Expert* is any domain expert invited to contribute to a specific study. *AgLINK* is responsible for searching and inserting new links in the database, *AgWEB* recovers information from the registered web links, *AgRESULT*, matches the pages content with the query, beyond executing data cleaning, and *AgWORD* is responsible for verifying the cooccurrence of words in the documents and creating the word maps.

The process starts with the login of the *Study Manager*. Following, two non-exclusive paths are possible: *(i)* in the case of previous existing studies, with pending searches, related to the same manager, *AgLINK* activates *AgWEB* to retrieve and maintain the related information, and *(ii)* the manager registers a study, including the definition of the focus with the respective links, allowing *AgLINK* to notify *AgWEB* to access the links and keep the information retrieved. This agent checks for the existence of links recorded in the database. Next, the page content is inserted in the database by request of *AgWEB*, that notifies *AgLINK* and *AgRESULT* to access the webpage content and search its weblinks. *AgRESULT* takes the inserted content and proceed to preprocessing actions. After that, *AgWEB* interactions are completed.

4.4 Data Model

The application handles 15 tables accounts of the data model required for persistence: *(i)* the study domain, *(ii)* status of the study, *(iii)* dictionary for keeping synonyms; *(iv)* stopwords; *(v)* website links; *(vi)* relationships among the studies and links; *(vii)* studies; *(viii)* words related to the studies; *(ix)* words related to a possible signal; *(x)* weak signals; *(xi)* relationships among words and the webpages; *(xii)* recovered links in a webpage; *(xiii)* interchange of messages among managers of studies and invited experts; *(xiv)* invited experts; and *(xv)* contributions of invited experts in a discussion. Figure 4 shows de tables and its relationships and main attributes.

5 PROTOTIPATION

A proof of concept was developed under MIDAS in order to evaluate the specification. The development process includeds four steps described next.

I. Parameterization of Internet Search. The first step is to insert information to drive the search. A search expression must be provided to works as a guess for finding information in the Web. The search may be linked to a domain (technological, governmental, environmental, etc.). Optionally, some sites may be informed to be accessed as source of information.

II. Retrieving Information from the Internet. After the search begins, agents take action by scanning the database. *AgLINK* accesses each of the links found in

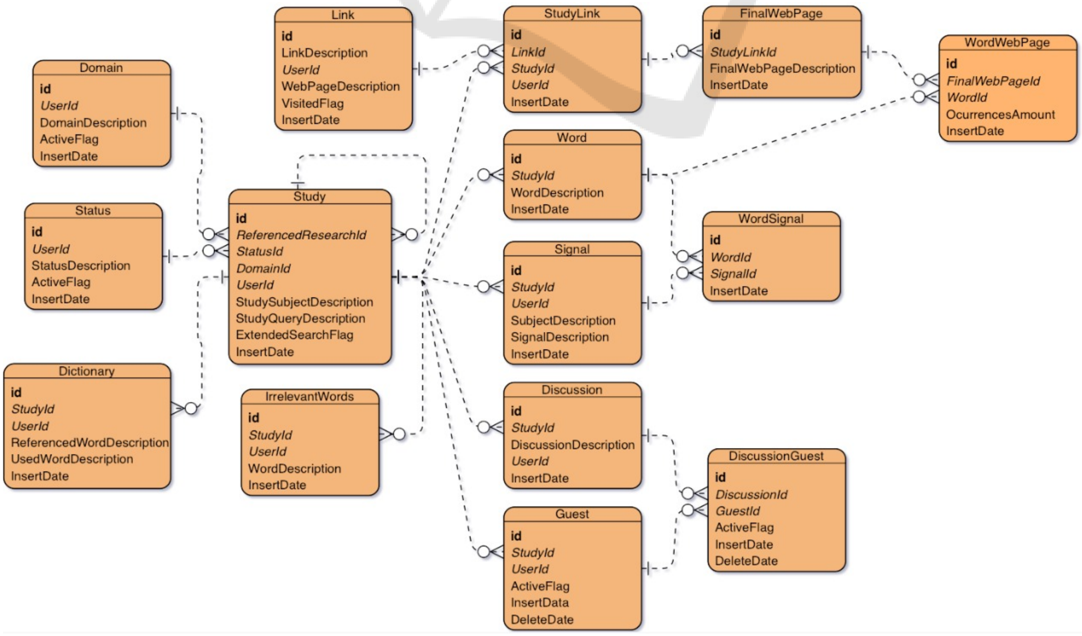

Figure 4: Data model and relationships.

the database in order to find more links and register them. At the same time, *AgWEB* retrieves the links and accesses the content, storing them in a database.

III. Analyzing the Recovered Information. As the website information is collected and stored, *AgRESULT* starts the pre-processing. This involves differentiating content and html tags, removing stopwords, unifying words or synonyms, removing scores, and checking whether the content is linked to the search. After preprocessing, a quantitative analysis is carried out by *AgWORD*, that produces a word map (Figure 5). It is the main analysis tool issued to the participants of the study.

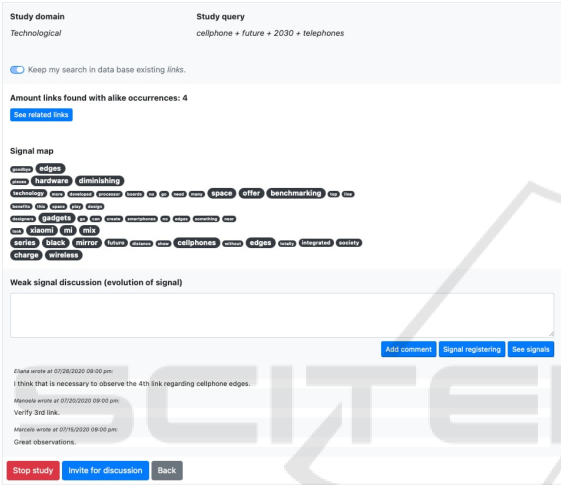

Figure 5: Word map GUI.

IV. Using the Prototype. The participants were invited to evaluate the tool by navigating in it functionalities, exploring creation of word maps and the signals that may arise from this representation. The identification of a weak signal is completed after a discussion that takes into account the different views on the word map.

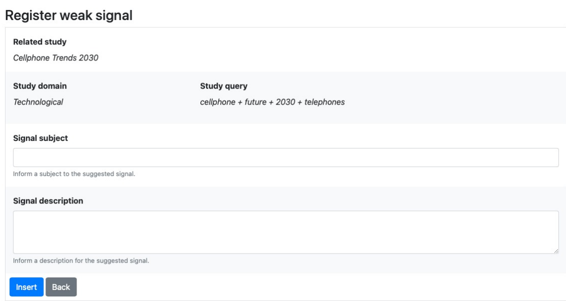

Figure 6: Inserting a weak signal.

A weak signal is registered as shown in Figure 6. One of the basis for getting insights from a weak signal is to establish an active discussion, under different perspectives and with different actors (Mendonça, Cardoso and Caraça (2012).

6 FINAL REMARKS

This paper faces the challenge of identifying weak signals with potential to be disruptive in a possible future and a certain domain. The huge and increasing volume of information the intelligence activity has to deal with in this context can be widely facilitated by this kind of computational support.

It is proposed a MAS conceptual model and a design, including requirements, actors, and use cases, as a solution for this problem. A prototype was developed as a proof of concept and an evaluation by experts in future studies was carried out.

Some future works for enriching such specification are *(i)* the inclusion of other sources of information (e.g., social networks), *(ii)* adoption of an ontology in order to have a uniform vocabularies for each domain.

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