A Conceptual Group Decision Support System for Current Times: Dispersed Group Decision-Making

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Abstract. We are living a change of paradigm regarding decision-making. On the one hand, there is a growing need to make decisions in group at both professional and personal levels, on the other hand, it is increasingly difficult for decision-makers to meet at the same place and at the same time. The Web-based Group Decision Support Systems intend to overcome this limitation, allowing decision-makers to contribute to the decision process anytime and anywhere. However, they have been defined inadequately which has been compromising its success. In this work, we propose a conceptual definition of a Web-based Group Decision Support System that intends to overcome the existing limitations and help them to affirm as a reliable and useful tool. In addition, we address some crucial topics, such as communication and perception, that are essential and sometimes forgotten in the support of dispersed decision-makers. We concluded that there are still some limitations, mostly in terms of models and applications, that prevent the design of higher quality systems.

Keywords: Group Decision Support Systems, Dispersed Group Decision-Making, Dialogue Games, Affective Computing.

1 Introduction

A group decision-making process consists in a process in which a group of people act collectively in order to select one or more alternatives to solve a certain problem [1]. At first sight, it seems to be an easy process. However, the reality tells us the opposite. Firstly, there are a set of possible alternatives which are defined according to a set of, usually conflicting, criteria. Secondly, there are too many psychological factors that affect the process, such as: social comparison, different intentions, interpersonal relationships, among others [2]. Lastly, if we consider the existence of all these issues in a dispersed context the complexity increases exponentially [3].

The Web-based Group Decision Support Systems (GDSS) have been studied since the beginning of the 21st century and they intend to support the group decision-making process anytime and anywhere [4]. They distinguished from conventional GDSS because they operate on the Web, which make them available by simply having an internet connection [5, 6]. However, if the general opinion is that these systems are crucial to the current times, the fact is that they have been struggling to impose [4, 7]. The research under this topic has been mostly oriented to study models that are capable of proposing solutions according to the decision-makers' preferences. Still, a group decision-making process is much more than just an outcome [8]. In face-to-face meetings, decision-makers communicate (through verbal and nonverbal communication) in order to exchange perspectives, allowing them to reason, to argue, and to create new intelligence [9]. It is all this interaction that composes the process that makes face-to-face meetings advantageous when compared with individual decision-making [10]. Therefore, a system that does not allow decision-makers to benefit from these advantages, will not be seen as a valuable asset and consequently as something worth to use. Even if just hypothetically, it is capable of proposing the best solution for a certain problem according to the decision-makers' preferences, but it is not capable of "explaining" the reasons behind that proposal, two things can happen: (1) the system will not be seen as reliable and the proposal can be seen as some kind of guess and (2) this behavior would impede the creation of new intelligence which annihilates all the advantages associated to conventional group decision-making.

The aim of this paper is to present a conceptual Web-based GDSS especially designed for dispersed group decision-making. The proposed approach presents a set of essential features to achieve the system's success and acceptability. Considering these features, we also propose a set of strategies to implement them. In addition, some important topics that are sometimes ignored under the group decision-making context are addressed.

The rest of the paper is organized in the following order: in the next Section, we describe the proposed Web-based Group Decision Support System's conceptual model, mostly in terms of features and architecture. In Section 3, we present a conceptual strategy to represent decision-makers under dispersed contexts. In Section 4, we analyze possible perspectives to support and recommend dispersed decision-makers in the decision-making process. In Section 5 the discussion is presented. Finally, some conclusions are put forward in Section 6, alongside with suggestions of work to be done hereafter.

2 The Web-based Group Decision Support System's Conceptual Model

This work distinguishes essentially by the way how the problematic of group decision-making support is addressed. Rather than idealizing the system in turn of a model capable of proposing a solution according to certain configurations, our focus is on allowing decision-makers to benefit from the typical advantages associated with face-to-face group decision-making processes.

We propose a Web-based GDSS inspired in the behavior of a social network like Facebook or LinkedIn. That means, the system should potentiate the interaction between decision-makers. The issues are discussed in the form of topics and everyone can add comments and replies. The system's main features are (Fig. 1): the ability to foster communication between decision-makers; the ability to represent decision-makers in terms of preferences, intentions, goals, desires, interests, beliefs, social standing, credibility and expertise; to help decision-makers perceive the process in terms of how the decision and everything that composes the context evolves over time; and finally, a set of strategies that support decision-makers through proposals, recommendations, predictions, relevant information, among others.

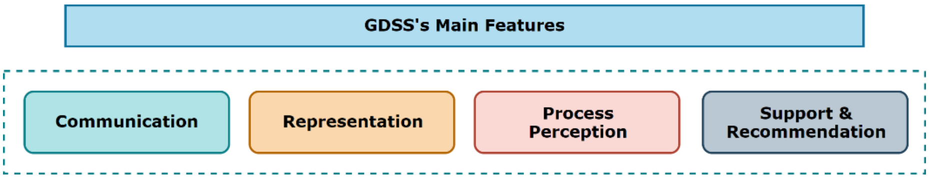

Fig. 1. Main features of the proposed Web-based GDSS.

2.1 Conceptual flow

Communication is the key ingredient of a group decision-making process. Thus, we propose a system that potentiates the communication between decision-makers. Obviously, it is different to communicate in face-to-face contexts and through an online application [11, 12]. So, the communication should be more structured than the one practiced in presential contexts. With a more structured type of communication the system will be able to make use of the conversations made by decision-makers to support the decision-making process and for autocomplete purposes, for instance, in the definition of multi-criteria problems or/and in the identification of alternatives and criteria. Another important aspect is that internet users are already used to social networks, which facilitates the understanding that each subject should be debated on a different topic. Other important strategies such as the use of "Likes (thumbs up)" and other forms of expression can also be used, since it is something that people are already used to and can serve as strategies that allow to better understand the level of acceptance of different ideas and the level of importance of the different subjects. Fig. 2 represents (in a non-formal format) the activities carried out by decision-makers in the use of our conceptual proposal. As we can see, decision-makers can communicate even if they are not (yet) involved in a decision-making process. We consider that the identification of a problem can occurs in a normal dialogue. So, this is the first step to start a decision-making process. After that, a decision-maker can create a new problem or submit a ticket asking a facilitator to create the group decision-making (GDM) problem. When a problem is created and the participants are added to the process, each participant can then start by some initial configurations. This is the first time that decision-makers (in general) interact with the new decision-making process and where they can define important stuff such as: their expertise level, their intentions and point other decision-makers as experts in that topic. In this way, they are modelling their representation and helping the system understanding all the context. All these steps can be revisited at any time and decision-makers can perform many reconfigurations as they want. In fact, the system can make use of these changes to better understand the process and consequently to create intelligence. After that, and if alternatives and relevant criteria are not yet defined, the system should provide conditions to perform the idea generation step. The most structured type of communication used by the means of the system will help in the organization of different ideas, in the identification of alternatives and of the most important criteria.

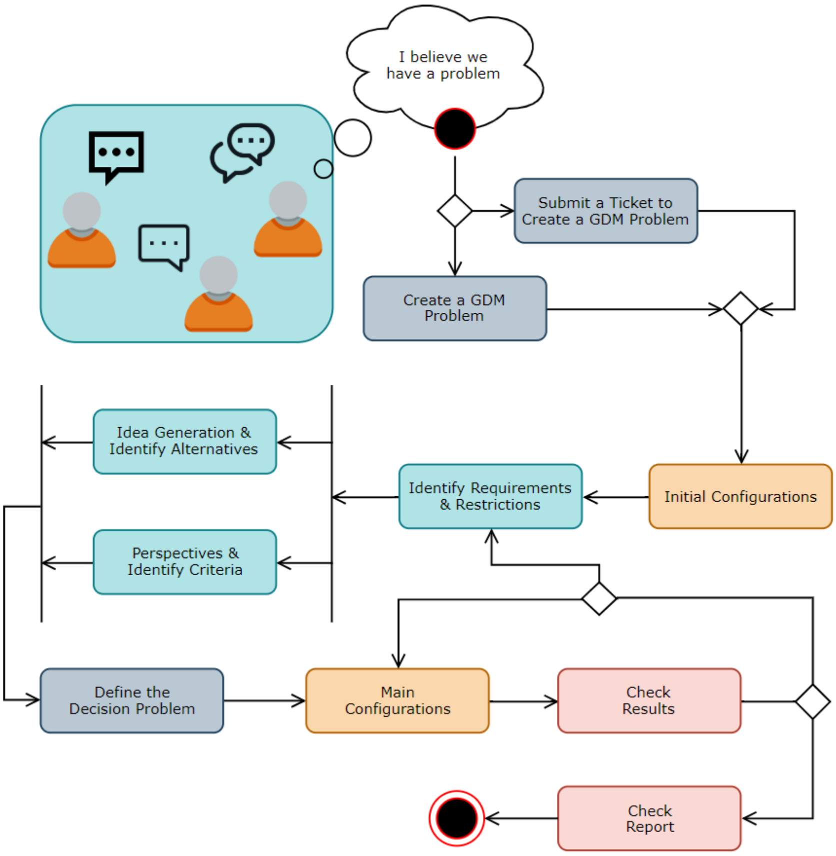

Fig. 2. Representation of the activities carried out by decision-makers in the use of the system.

After all the different possible alternatives are identified, the decision problem should be defined, for that Artificial Intelligence techniques can make use of the dialogues performed by decision-makers in the previous steps. Techniques to extract knowledge can be used in here. The definition of the decision problem should not be costly because the different alternatives were in majority referred before, such as the most important criteria. When the decision problem is defined, decision-makers can then configure their preferences regarding not only alternatives and criteria, but also regarding limitations, desires, goals and their group position in terms of opinion. This seems complex but it can be done through simple “clicks” using configuration templates with high usability. Right after decision-makers perform their configurations, many Artificial Intelligence techniques can be used to propose solutions, to search inconsistencies, to present relevant information and to support/recommend decision-makers. Decision-makers do not need to be aware of this level of complexity, but the strategy used to present the information to them is vital. That means, the communication between the system and each decision-maker should be adapted to his/her preferences and interests, and the system should be capable of understanding how much each decision-maker is involved in the process. Obviously that the capacity to propose solutions is intrinsic to this kind of systems, but in this conceptual proposal the major objective is the walk to find the solution. The system should be aware of the process importance, which means that the system should be intelligent enough to understand how important to mature ideas, to exchange perspectives and to reflect is, in order to potentiate the decision quality. When a consensus is reached or the satisfaction level attained is enough, the process ends, and a final report is presented. Otherwise, the previous steps can be revisited. Finally, the system should be capable of using all the data generated during the process, to document the reasons that led the group to make that decision and the impact that each decision-maker had in the process. This will turn into valuable information for the organizations because they can, in the future, understand the reasons that made them take those decisions and the responsibility/contribution that each decision-maker had (either for the good or bad decisions). Also, Artificial Intelligence techniques can be used in these reports to learn from past experiences in order to make better predictions and recommendations.

2.2 Architecture

The literature is not rich in terms of architectures for Web-based GDSS, though in a first instance, a Web-based GDSS differs from a conventional GDSS mostly because of its architecture. In this work, we propose a microservices-based architecture (Fig. 3) because it empowers a lot of benefits for the context of the proposed system (group decision-making with dispersed participants) and for the current context of the major organizations. If we think in terms of the number of features a system like this has to provide (and the number of different algorithms and models used), a microservices-based architecture allows to: get a better faults isolation, perform continuous delivery, have components spread across multiple servers, be easily understood since they represent small pieces of functionality, etc.; and from the organizations perspective it allows to: organize the code around business capabilities, use complement cloud activities, write code in different languages, get an easy integration, perform automatic deployment, etc. [13].

Fig. 3 represents the conceptual Web-based GDSS proposed in this work. It uses a standard microservices architecture. There is an API Gateway that works as a single-entry point into the system, which allows the internal system architecture to be encapsulated and to provide an API that tailors to each client. In addition, we consider that features such as authentication, monitoring, load balancing, among others, are also responsibilities of the API Gateway.

We consider the existence of a set of possible microservices/services that satisfies the business of the organization (accounts, products, etc.) and a set of microservices that intends to support the decision. In this conceptual proposal we consider several Artificial Intelligence's strategies (which are explored in Section 4). Each strategy has special needs and is implemented using different programming languages. Thereby, a microservices-based architecture becomes even more relevant because this way each service is independently deployable, loosely coupled, highly maintainable and testable, easier to understand and is relatively small.

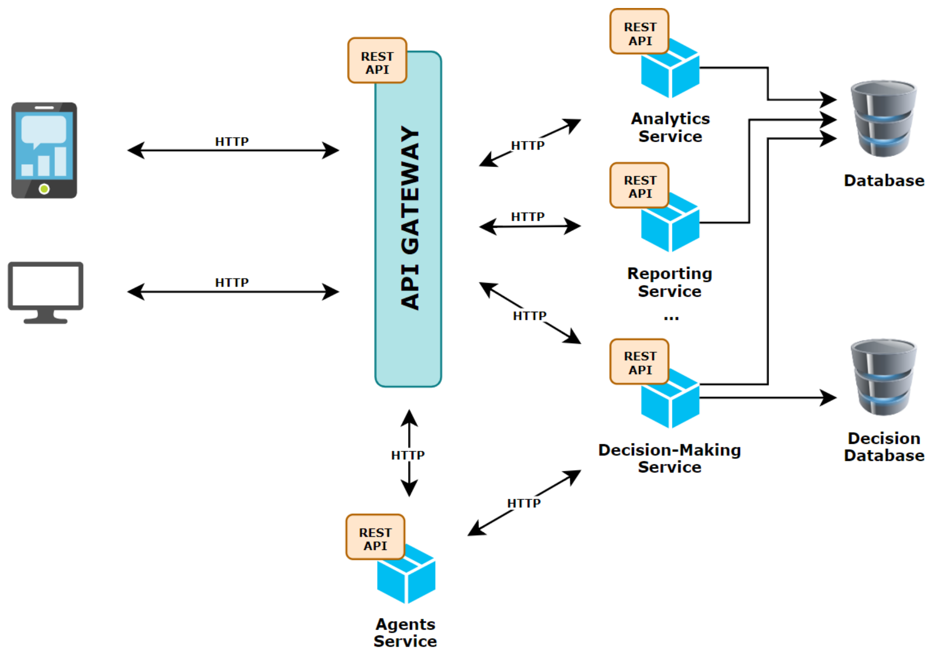

Fig. 3. The Group Decision Support System's Conceptual Architecture.

In this proposal, we pay particular attention to the "Agents Service" and to the "Decision-Making Service". The "Agents Service" is the microservice that encapsulates the Multi-Agent System existent in the Web-based GDSS and where the main agents' platform stands. In the "Agents Service" the information that circulates in the system is analyzed and processed by the agents when necessary. The "Decision-Making Service" is responsible for the strategies used to automatically propose solutions and where exists another agents' platform to work with contextual agents (or clones like we will see in Section 3).

3 Decision-Makers Representation

In this conceptual approach, we consider some aspects regarding the decision-makers representation. We propose the use of a multi-agent system in which each decision-maker is represented by an agent. From now on we call each of these agents as participant agents. As has been said, a participant agent represents a decision-maker, that means a participant agent should be modelled with the characteristics of that decision-maker in order to represent him/her accordingly. However, there are three aspects that affect exponentially the complexity of modeling agents in this context. First, decision-makers behave differently according to the situation's characteristics (for instance, how much a decision problem means to them) [14], second, these different behaviors are always affected by the decision-makers' personality traits (which are more constant) and third, the decision-makers' knowledge evolves over time.

In Section 2.1 we referred that the multi-agent system is part of the "Agents Service", however, this is not the only agents' platform in the proposed Web-based GDSS. We consider the existence of another agents' platform in the "Decision-Making Service". So, the participant agents in the "Agents Service" represent decision-makers in terms of what they are, more specifically, these agents are modelled with personality traits of the decision-makers they represent and each one has a knowledge base, where the history of everything that matters is saved. It is considered that the participant agents in the "Agents Service" are always active and can be working even when the decision-makers they represent are not involved in any process. They can be processing the decision-makers dialogues, for instance, to study relationships, the evaluations made by other decision-makers to their comments, who usually support them, who usually criticized them, among others. Regarding the agents in the "Decision-Making Service", they represent decision-makers in a context, and they are alive only during the existence of that process. These agents can be modelled with other characteristics, such as: the decision-maker's intentions, which other decision-makers they consider credible, decision problem preferences, etc. These agents can use other Artificial Intelligence techniques in order to better understand the process impact, such as an emotional model. In terms of flow, when a decision-maker is added to a new decision problem, a new participant agent is created in the "Decision-Making Service". This participant agent is a clone of the participant agent existent in the "Agents Service". This approach presents several benefits because it avoids problems when a decision-maker is involved in too many decision problems at the same time, it separates the impact that each process has in the participant agent and makes it easier to manipulate the temporary knowledge and the knowledge that should be persistent.

4 Group Support and Recommendation: Possible Perspectives

Support and recommendation go hand in hand in terms of systems being capable of helping users attaining something better. Decision support techniques and recommendation techniques can both be used to help decision-makers during the process. In this proposal, we consider a set of different techniques to support decision-makers in the group decision-making process. However, due to the nature of the proposed architecture, the system is prepared to grow up and new strategies can be included over time. Moreover, as the proposed architecture is microservices-based, it becomes a lot easier, in terms of scalability and reusability, to work with containers and to monitor them.

As we have seen, a Web-based GDSS should provide good enough conditions so decision-makers can communicate. In this conceptual proposal, this is accomplished through the natural interaction existent in a social network.

Besides communication, there are other tasks that the system should be able to facilitate, such as the creation of new problems. It is known that to define a new decision problem is complex and time-consuming. There are always several alternatives, different criteria types, several decision-makers, etc. So, it is important to use at least 2 different strategies for this purpose: (1) text analytics, to automatically suggest based on the previous dialogues, alternatives, criteria and decision-makers, and (2) algorithms such as case-based reasoning, to predict the possible alternatives and criteria types based on previous problems.

Regarding the strategies to automatically propose a solution to the group, we consider in a first instance a dialogue-based argumentation model and in a second instance a multi-criteria decision analysis (MCDA) model. The former intends to be capable of proposing solutions and at the same time, due to its self-nature characteristics, to be capable of explaining the reasons that lead to the proposition of those solutions. This allows decision-makers to feel part of the process and to understand it accordingly. As they understand the motifs behind the proposed solutions, they can reason about those motifs and consequently it becomes easier to accept or to reject the proposed solutions. We consider a dialogue-based argumentation model with a high level of expressiveness, that means, the participant agents are capable of behaving according to different intentions in the same dialogue. In addition, the participant agents can use the same locution for different purposes (for instance, to persuade or to deliberate) and the identification of these intentions is a responsibility of the other participant agents. The latter intends to work as a detector of inconsistencies. It is extremely important to perceive if the preferences configuration made by each decision-maker makes sense. For instance, let us imagine a decision-maker that considers the price as the most important criterion, but at the same time his/her preferred alternative is the most expensive; it is important to understand if there are not big price differences between alternatives or if he/she made a mistake in the configuration process or if there are subjective reasons behind his/her configuration. We consider that a MCDA model can be extremely helpful in the detection of these inconsistencies.

Considering the number of messages exchanged in a system like this, it is fundamental to study the produced dialogues. For that, we consider the use of two main strategies: text analytics and natural language processing. In this way, the system can study the dialogues and produce important information regarding not only the dialogues structure but mostly in terms of their meaning and the sentiment existent in them. In addition, classic algorithms from the social networks' literature can be used to understand the impact/importance of each message/topic. This information can be used by each agent in the dialogues to better represent their decision-makers' needs/intentions.

Finally, it is important to use strategies that allow to learn, classify, predict and recognize patterns. For that, we consider the use of machine learning algorithms, more specifically, deep learning and reinforcement learning algorithms. With these algorithms each participant agent (in the "Agents Service") will be capable of presenting important information about other decision-makers, about the decision processes (previous and actual) and about things that matter in general to the decision-maker it represents.

5 Conclusions and Future Work

Web-based GDSS have been studied in the last years in order to develop solutions capable of supporting decision-makers anytime and anywhere. They differentiate from conventional GDSS because they operate on the web and so, decision-makers only need to have an internet connection to use them. However, GDSS in general are having problems to establish and to be recognized as a useful tool by organizations. We believe that this is due to the way they have been addressed, which is focused in the outcomes rather than in the decision-makers' needs.

In this paper we propose a conceptual Web-based GDSS that intends to enable decision-makers to benefit from the typical advantages associated to face-to-face decision-making. Our approach allows decision-makers to interact as people do in social networks, which naturally promotes the communication and the interaction between them. In addition, our proposal is based in a microservices architecture that demonstrates a lot of benefits in a system where so many different Artificial Intelligence techniques are implemented. However, we found some limitations that impede to implement an approach like this now, such as: rudimentary tools to develop multi-agent systems, lack of psychological models that can be computerized, and dialogue-based argumentation models not intelligent enough.

As future work, we want to continue digging under the topic of GDSS. After identifying a set of issues that are compromising the GDSS success and a set of possible solutions, we now intend to work in order to make this conceptual model real. We intend to develop dialogue-based argumentation models in which not only the messages exchanged by the agents are perceptible to decision-makers but also the intentions behind the messages.

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