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UbiGDSS: A Theoretical Model to Predict Decision-Makers' Satisfaction

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Abstract

The market globalization and the firms' internationalization hinder the matching of the top managers' agenda, making it difficult to meet in the same space or time. On the one hand, the appearance of Ubiquitous Group Decision Support Systems (UbiGDSS) enabled individuals to gather and make decisions in different spaces at different times, but on the other hand, originated problems related to the lack of human interaction. To understand how the arguments used can influence each of the decision-makers, what is their satisfaction regarding the decision made, and other affective issues such as emotions and mood, are some examples of that lack. In order to try to overcome this lack, we propose a theoretical model that is specially designed for agents, helping to understand the interactions impact on each agent and their satisfaction with the decision made.

Keywords: *Decision Support Systems, Ubiquitous Computing, Decision Satisfaction, Affective Computing, Automatic Negotiation, Argumentation*

1. Introduction

Nowadays the decisions made by managers and executives are mostly performed in groups. Thereby, group decision-making is a process in which a group of people, called participants, act collectively analyzing a set of variables, considering and evaluating the available alternatives in order to select one or more solutions. The number of participants involved in the process is variable and all of them may either be at the same place at the same time or geographically dispersed at different times [1].

Aiming to satisfy all these requirements, GDSS (Group Decision Support Systems) have adapted and evolved in time, incorporating new features and modifying their architectures. Due to the costs in creating conditions that allow participants to meet in the same place at the same time (time, travel, *etc*.), the Ubiquitous GDSS (UbiGDSS) appeared, allowing decision-makers to contribute with their ideas to the decision process anywhere, anytime [2].

One of the great problems associated to the use of UbiGDSS is the difficulty to understand the decision makers' satisfaction with the decision made, problem that also exists in decision processes that do not use a GDSS. Being satisfaction a strong indicator of the decision quality in the perspective of each participant, its study is very relevant. Higgins [3] says that "a good decision has high outcome benefits (it is worthwhile) and low outcome costs (it is worth it)", and that "independent of out-comes or value from worth, peo-

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ple experience a regulatory fit when they use goal pursuit means that fit their regulatory orientation, and this regulatory fit increases the value of what they are doing". With this, it is possible to understand that the decision quality in the perspective of each participant is related to what he considers relevant. Satisfaction is therefore a strong indicator, not only of the results, but also of the whole decision process. There is a great variety of factors responsible for affecting the satisfaction of a decision-making element with the decision made in a meeting: emotional variables (affective components) [4-6], the process [7,-8], the outcomes [3], the factors that affect the situation [9] and expectations [10-11].

The goal of this paper is to help understand the decision quality achieved through an ubiquitous group decision support system and overcome the problems associated with the lack of human-interaction. Aiming to contemplate different approaches from researchers of a wide range of areas in this thematic (computer sciences, psychology, economy, *etc*.), a theoretical-based model is presented seeking to include in the satisfaction analysis all the necessary variables. This paper is an extended and improved version of the paper "Overcoming the Lack of Human-Interaction in Ubiquitous Group Decision Support Systems" [12].

The rest of the paper is organized as follows: Section 2 presents the literature review of Ubiquitous Group Decision Support Systems and satisfaction analysis, followed by Section 3 that presents the proposed model. Section 4 describes a practical way to implement all the points that compose the model. Finally, some conclusions are taken in section 5, along with the work to be done hereafter.

2. Literature Review

The GDSS emerged to help support the decision-making groups in the decision-making process. According to Detmar and Renée [13], "a GDSS can be any technology used to improve the quality of group decision-making. The assumption is that GDSS can help groups reach higher quality decisions, stimulate more equitable and useful interactions, and reduce the negative aspects of small group decision-making".

One of the first persons to approach the ubiquitous computing was Mark Weiser [14]. Mark "anticipates a digital world which consists on many distributed devices that interact with users in a natural way" [14]. Ubiquitous computing is the ultimate cleavage of action from the "here and now". Currently there is the interest in developing Group Decision Support Systems which are also ubiquitous systems. With the development of such systems it is possible for the decision-makers to contribute with their ideas to the decision process anywhere and anytime [2]. This allows having better experts "present", even when they are on the other side of the world. This approach makes sense in many areas where the decision-making is required. One of the most cited areas in literature is Healthcare, since patients treatment involves various specialists, like doctors, nurses, laboratory assistants, radiologists, *etc* [15-17]. Recent studies claim that UbiGDSS will be the next generation of Decision Support Systems [18]. Figure 1 has been adapted from the work developed by Kwon and his colleagues [18] and shows the path taken by Decision Support Systems.

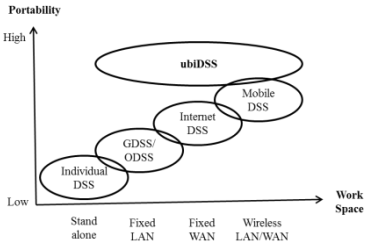

Figure 1. Locus of UbiGDSS [18]

But then, what are UbiGDSS? In which ideas are they based and what needs they seek to fulfill? The UbiGDSS are characterized by their ability to identify decision-makers even when they are mobile, and to allow them to acquire solutions through any portable device on any workplace. As the capabilities of mobility and portability are included into DSS, the notion of providing management-critical information or decision support anytime, anywhere, can be realized [19].

There are already some examples of GDSS that support ubiquitous decision as Web-meeting [20] and HERMES [21].

Web-meeting is a GDSS that supports distributed and asynchronous meetings through the Internet (ubiquitous meetings). The Web-meeting system is focused on multi-criteria problems where there are several alternatives that are evaluated by various decision criteria. Moreover, the system is intended to provide support for the activities associated with the whole meeting life cycle from the pre-meeting phase to the post-meeting phase. The system aims at supporting the activities of the two distinct types of users: ordinary group "members" and the "facilitator". Web-meeting users can access the system from anywhere through a PC and an Internet connection [20].

HERMES is a web-based GDSS that supports argumentative discourses between group members. The agents role in this system is, for instance, to provide mechanisms to validate the arguments consistency as well as to weight them. Agents in Hermes are also responsible for processes related with information search, *e.g.*, recovering information from previous discussions [21].

Other very relevant topic when talking about ubiquitous computing and ubiquitous decision support activities is the context. Context underpins every process for making decision. The context mentioned in an ubiquitous computing environment is conceptualized as any useful information to characterize the situation of an entity [22]. The information indicates any place and action, or even any event caused by them. Due to the fact the information possesses users' external and internal intention, by identifying and analyzing the context, we can forecast the following events that will be confronted by users, namely decision- makers.

A work developed by Marreiros and her colleagues [23], called Agent Based Simulator for Group Decision (ABS4GD) combines an UbiGDSS with human features, such as intelligence and emotions. This system has the goal of supporting the decision makers and implements a multi-agent architecture. In this system, each agent represents a decision maker and can be used through different types of devices, being only necessary to have an internet connection.

Another very important point in the history of GDSS is the emergence of the need to examine satisfaction with the use of such systems, with the process used and the results. There is a great variety of factors responsible for affecting a decision-maker satisfaction with the decision made in a meeting: emotional variables (affective components) [4-6], the process [7,-8], the outcomes [3], the factors that affect the situation [9] and expectations [10, 11].

Briggs, de Vreede, and Reinig [24] presented a theory of meeting satisfaction, which explains the causes of conflicting research results on meeting satisfaction, as these results have never been fully explained in the group support systems literature. Therefore, their theory tries to contribute to a possible development of systems and methodologies that increase group efficiency and group effectiveness, without decreasing meeting satisfaction. The authors proposed and tested the Satisfaction Attainment Theory (SAT) – a causal model of meeting satisfaction. Taking into account the SAT assumptions, satisfaction, *i.e.*, the affective arousal with a positive valance a person felt after a meeting would be a function of the perception that, balancing conflicting and mutually exclusive goals, the value of one's goals increased, or the likelihood of their success increased because of the meeting. Meetings that produce positive Perceived Net Goal Attainment (PNGA) should also produce high levels of meeting satisfaction and meetings that produce negative

PNGA should also produce low levels of meeting satisfaction. Finally, Briggs, de Vreede, and Reinig have defined meeting satisfaction as an affective arousal with a positive valance of a participant towards a meeting. However, other researchers may choose to define meeting satisfaction according to other factors, such as the degree to which a meeting has fulfilled certain requirements. The difficulty to provide a clear definition of meeting satisfaction reduces the degree to which research on meeting satisfaction can be generalized.

Yuan [25] conducted a study on how to measure satisfaction based on the emotional space. The satisfaction measured sought to understand the users' acceptance for a product by testing usability. In order to analyze the emotional space, they used the PAD (Pleasure, Arousal and Dominance) model proposed by Mehrabian [26]. To find out his initial emotional state the user must answer to the Big Five Inventory questionnaire [27], and with the obtained personality he is given a standard emotional state. The emotions generated during the test are detected by observing the user's behavior. These emotions decay through the process, getting closer to the initial state, as can be seen in Figure 2.

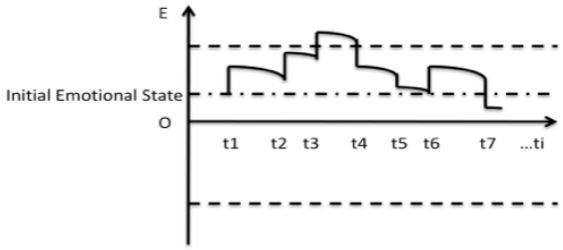

Figure 2. Changes of Single Dimension in PAD Model, Adapted from [25]

After performing the test and building the emotional map, emotions' changes are registered and their sum is calculated. With the emotional values, interesting conclusions are attained. The authors claim that "with a good pleasure emotional state, users can have a smooth thinking and judgment to choose the most effective method to finish the task, so the pleasure state of the users can reflect the affinity and usability of the product in the testing. The arousal degree has a positive effect on usability, but the high level of arousal means that users are in a highly concentrated spirit and get tired easily; on the other hand, also means that users may be thinking about a way to solve the problems. So a lower level of positive arousal degree reflects the usability of the software operations. The improvement of the user domination means that users are in an intense state, and that has a negative effect on usability. High usability products should be consistent with the users' traditional habits, without the need to consider the controllable process and solutions of the product. Therefore, the domination degree indirectly reflects the extent of the ease of using the product."

In their work, Paul, Seetharaman, and Ramamurthy [28] explore how the performance of a GDSS affects the different satisfaction dimensions. They focus on three indicators of group performance, namely: the decision time, the efficiency in decision-making and the number of iterations in the group decision-making process. For each one of these indicators hypotheses that affect satisfaction are created. Example: "H1a – In a GDSS-supported group decision, the higher the decision time, the lower is the satisfaction of a group with the system used by its members." This model is based on hypotheses and can be verified in Figure 3.

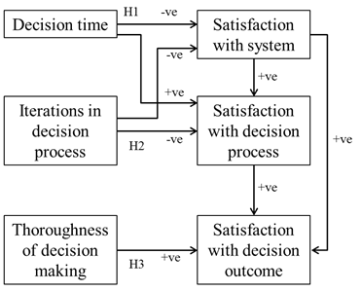

Figure 3. Paul, Seetharaman, and Ramamurthy [28] Research Model Based on Hypotheses

Some of the conclusions obtained from this work demonstrated that the performance of GDSS influences the group members' satisfaction. When decision time increases, the system appears to be unproductive and the group members' satisfaction with the system decreases. However, when GDSS meetings end quickly, members may perceive that they are rushed through the process and different alternatives of the decision situation are not adequately evaluated. This is evinced in the positive relationship between decision time and the members' satisfaction with the process. The authors found a positive relationship between thoroughness of decision-making and group members' satisfaction with the decision outcome.

3. Proposed Model

In this section we present the proposed model and how all model points are connected. For more information on the work that deduces the points of this theoretical model, the paper entitled "Understanding Decision Quality through Satisfaction" published in the WIHAS at PAAMS 2014 conference can be consulted [29].

3.1 Point 1 – Satisfaction Concerning the Chosen Alternative

According to literature, the perception of the decisions quality is related to the advantages the participant identifies in that alternative comparing it against the others. Thus, whereas the preferred alternative is the best in the participants' perspective, the distance between the preferred alternative and the chosen one means a loss of the participants' satisfaction regarding the decision. The loss of satisfaction comprises the difference in the assessment made by the participant for each of the alternatives, as well as what the participant did not achieve with the final decision. The participants' assessment of each alternative varies in a [0-1] range, where 0 means "I do not like at all" and 1 means "I like very much".

There are five different scenarios that may occur in a meeting, affecting the satisfaction differently:

1. The alternative chosen by the decision-makers is the one chosen as the preferred by the participant. At this point, his satisfaction is related to the assessment he makes on this alternative (Do not forget that it may be the preferred one and not being in anyway the alternative he finds brilliant. The preferred alternative may be one that was not even an option to choose from);
2. The participant starts the meeting with a preference of an alternative, he does not change his opinion during the process, but at the end the chosen alternative will always be one he never took into consideration;
3. The participant may start the meeting with a preference on an alternative and later switch to another one. However, the alternative chosen by the decision-makers ends up being the one he initially chose;

4. The participant may start the meeting with a preference on an alternative and later switch it to another one that eventually will be chosen;
5. The participant starts the meeting with a preference on an alternative, he changes his mind during the process, but at the end the chosen alternative will always be one that he never took into consideration.

Table 1 is a practical example of the occurrence of each one of the different scenarios.

Table 1. Different Scenarios in a Meeting that Affect the Satisfaction

Scenario	Initial Preferred Alternative	Preferred Alternative Changed	Chosen Alternative
1	A	-	A
2	A	-	B
3	A	B	A
4	A	B	B
5	A	B	C

3.2 Point 2 – Participants' Expectations According to the Decision and Process

Consciously or not, people create expectations on (almost) everything. The relationship between expectations and the satisfaction is rather obvious.

For instance, if someone's life goal is to have a yacht, but the expectations on the possibility to get it are extremely low, the fact of not getting the yacht will never have a notorious negative impact. But if someone has the objective to go on vacations next year and if the expectations for that to happen are really high, if that does not happen there will be a very strong negative impact. The same happens in opposite situations. According to assimilation theory [10], consumers experience a psychological conflict if they perceive a discrepancy between their expectations and their perception of the consumption experience [11]. Moreover, the nature of the expectation-satisfaction relationship may depend on several contextual and behavioral factors. So, users' expectations may have a different impact on the satisfaction formation within particular contexts. Expectations may even be more important when they are unambiguous [30] the product performance is ambiguous [31, 32] and/or the consumer is well experienced [33].

1. Complexity of the meeting: The participant should be questioned about how he thinks the meeting will be held, in order to reflect on whether he thinks it will have many conflicts and if the understanding among the participants will be problematic. And so, the following question can be asked: "Will this meeting be problematic?"
2. Probability of the participant's preferred alternative to be chosen: Understanding the expectations regarding the probability of the participant's preferred alternative to be chosen. "How likely you think your preferred alternative will be chosen?"

These two topics are the ones we consider most relevant for analyzing the expectations due to the impact the process and the results have on the participant, as previously stated. Besides that, these two topics are easier for the participant to classify regarding its expectations.

It is important to know the participants' expectations according to some issues, in order to have a more accurate perception of the satisfaction. We think it is important to study the participants' expectations on the following topics: complexity of the meeting and probability of the participant's preferred alternative to be chosen.

3.3 Point 3 – Factor Concerning the Personality

The personality is a concept that cannot be briefly defined, because it has a different meaning according to some psychologists who study it. Although most of them would agree that the field of personality is the study of how individuals differ from each other, psychologists would differ about the best way to conceptualize these types of differences [34]. The fact that people differ in their ideas and attitudes, makes them react differently

to the factors they are exposed to. Recently, satisfaction is being studied regarding the most different scenarios according to the persons' personality. For instance, Shiammack *et al.* [35] conducted a study on two factors of The Big Five that contribute to life satisfaction: the Neuroticism and the Extraversion. Another study was conducted by Timothy *et al.* [36], where they tried to establish a correlation between the values of each type of personality of The Big Five and Job satisfaction.

Knowing that the personality of each one of us influences satisfaction, we think it is relevant to take into account the personality on our analytical model of satisfaction.

3.4 Point 4 – Emotional Changes

Knowing the importance of the decision-making process, and to make conclusions about the participants' satisfaction regarding decision-making, it is necessary to understand what happens during the process. It is important to include in the satisfaction analysis affective and emotional components [4-6, 37].

Having said this, we want to include, at this point, the analysis of generated emotions and to know how they can change the participants' mood. There are two important points to be studied:

1. The sum of emotional spaces that exceed positively or negatively the participant's normal state: it is thus possible to measure the emotional cost that the meeting had on the participant;
2. The participant's mood at the end of the meeting.

To make this clearer, Figure 4 illustrate the impact of each point of the model in the process of measuring satisfaction. At the moment this is a preliminary process that intends to show how everything fits together from a theoretical point of view.

Initially, satisfaction is calculated taking into account the alternative chosen by the group (Point 1) and the emotional changes (Point 4) with the impacts caused by the expectations. After the values of these two points have been recalculated, the final values for each point are obtained for the calculation of satisfaction. Emotional changes, as well as personality, will also have an impact on the participant's satisfaction with the option chosen by the group.

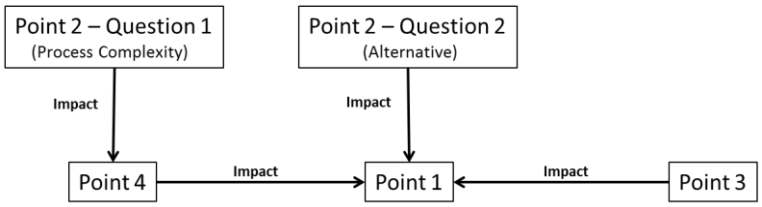

Figure 4. Impact Caused by Each of the Points of the Model

The use of the personality in the final calculation may not exist directly. This happens for example when we are dealing with a multi-agent system in which the arguments used by the agents are according to the identified personalities. This will generate emotions and the change of mood regarding the personality. Thus, Point 3 is not covered in the final formula despite being covered by the system indirectly.

The Figure. **5** shows how every points fix to each other and how they work together to turn this model possible.

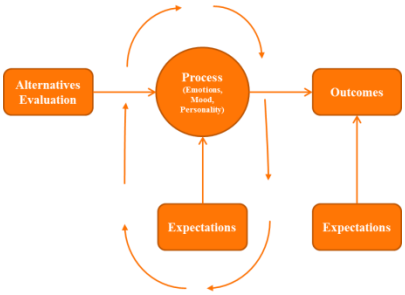

Figure. 5. Proposed Model

4. Agents Modeling

The model presented in last section addresses subjects such as emotions, mood, personality and expectations that nowadays are likely to be materialized through existing models. This section shows how we reasoned to develop an agent with such capabilities, turning possible the proposed model.

The implemented multi-agent system is based on the argumentation model proposed by Sarit Kraus [38]. Each agent represents a real decision maker and is denominated as participant agent. The agents use this model in order to persuade each other. The arguments used by each agent are selected taking into account the strength of the argument and the personality of the agent that is going to receive the argument. To define a personality, we used the Five Factor Model (FFM) [39]. To obtain the agent's initial personality, the decision-maker fills the Big Five Inventory [40], a questionnaire that measures the five factors that compose the FFM and therefore his personality. The arguments sent and received by the agents throughout the meeting process lead to the generation of emotions by them, which are according to the ones proposed by the OCC (Ortony, Clore, and Collins) model [41]. The generated emotions affect the agent's mood which is based in the PAD (Pleasure, Arousal, and Dominance) model [42]. In turn, the agent's mood affects the way he selects the arguments to send and how he evaluates the arguments received. A Visual Analogue Scale (VAS) was implemented to help the decision-maker evaluate his expectations. This scale consists on a 10 cm line segment where 0 means "not probable" and 10 "highly probable" and where the decision-maker is asked to select his expectation regarding a certain issue.

5. Conclusions and Future Work

Several concepts of ubiquitous computing, decision satisfaction and decision-making were presented in this paper. Concepts of satisfaction and the existing models to assess satisfaction were also presented. Furthermore, this paper proposed a theoretical model which intends the automatic assessment of the participants' satisfaction in a meeting, supported by an Ubiquitous Group Decision Support System. We believe that the proposed theoretical model allows the attainment of a large amount of useful and valuable information.

The theoretical model of satisfaction analysis presented in this paper was published in more detail in our previous work and was created after reading the literature on different areas (psychology, computer science, economy and sociology) and considering every point found as relevant in the literature.

As future work, we intend to conduct a case study with real people, in partnership with psychologists. With that work, we also intend to make the model more assertive by the possible improvements that might result after analyzing and studying the collected data.

Acknowledgements

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