COLLA 2017

The Seventh International Conference on Advanced Collaborative Networks, Systems and Applications

ISBN: 978-1-61208-575-3

July 23 - 27, 2017

Nice, France

COLLA 2017 Editors

Elena Troubitsyna, Abo Akademi, Finland

Alberto Turón, University of Zaragoza, Spain

Lasse Berntzen, University College of Southeast Norway, Norway

COLLA 2017

Foreword

The Seventh International Conference on Advanced Collaborative Networks, Systems and Applications (COLLA 2017), held between July 23 - 27, 2017 - Nice, France, continued a series of events dedicated to advanced collaborative networks, systems and applications, focusing on new mechanisms, infrastructures, services, tools and benchmarks.

Collaborative systems became a norm due to the globalization of services and infrastructures and to multinational corporation branches. While organizations and individuals relied on collaboration for decades, the advent of new technologies (Web services, Cloud computing, Service-oriented architecture, Semantics and Ontology, etc.) for inter- and intra-organization collaboration created an enabling environment for advanced collaboration.

As a consequence, new developments are expected from current networking and interacting technologies (protocols, interfaces, services, tools) to support the design and deployment of a scalable collaborative environments. Innovative systems and applications design, including collaborative robots, autonomous systems, and consideration for dynamic user behavior is the trend.

We take here the opportunity to warmly thank all the members of the COLLA 2017 Technical Program Committee, as well as the numerous reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to COLLA 2017. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the COLLA 2017 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that COLLA 2017 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of collaborative networks, systems and applications.

We are convinced that the participants found the event useful and communications very open. We also hope that Nice provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city.

COLLA 2017 Chairs:

COLLA Steering Committee

Lasse Berntzen, University College of Southeast, Norway
Thomas Schuster, University of Applied Sciences Pforzheim, Germany
Mudasser F. Wyne, National University, USA

COLLA 2017

Committee

COLLA Steering Committee

Lasse Berntzen, University College of Southeast, Norway
Thomas Schuster, University of Applied Sciences Pforzheim, Germany
Mudasser F. Wyne, National University, USA
Wolfgang Mauerer, Technical University of Applied Sciences Regensburg / Siemens AG Corporate Research, Germany
Hassan A. Karimi, University of Pittsburgh, USA
Atsuo Hazeyama, Tokyo Gakugei University, Japan
Yung-Ting Chuang, National Chung Cheng University, Taiwan

COLLA Industry/Research Advisory Committee

Jingjing Wang, Google, USA
Niyati Chhaya, Adobe Research, India
Giuliana Dettori, Istituto per le Tecnologie Didattiche, Genova, Italy

COLLA 2017 Technical Progrm Committee

Imad Abugessaisa, RIKEN, Japan
David Airehrour, Auckland University of Technology, New Zealand
Jameela Al-Jaroodi, Robert Morris University, USA
Mehdi Ammi, LIMSI-CNRS - University of Paris-Sud, France
Leonidas Anthopoulos, University of Applied Science (TEI) of Thessaly, Greece
Alessio Antonini, Università degli Studi di Torino, Italy
Marcelo Armentano, ISISTAN Research Institute (CONICET/UNICEN), Argentina
Liz Bacon, University of Greenwich, UK
Lasse Berntzen, University College of Southeast, Norway
Niyati Chhaya, Adobe Research, India
Jin-Hee Cho, U.S. Army Research Laboratory (USARL), USA
Christina Christodoulakis, University of Toronto, Canada
Yung-Ting Chuang, National Chung Cheng University, Taiwan
Neil Croft, University of Pretoria, South Africa
Antonio De Nicola, ENEA, Italy
Giuliana Dettori, Istituto per le Tecnologie Didattiche, Genova, Italy
Arianna D'Ulizia, National Research Council - IRPPS, Italy
Wael M El-Medany, University of Bahrain, Bahrain
Hossein Fani, University of New Brunswick, Canada
Camille Fayollas, ICS-IRIT | University Toulouse 3 Paul Sabatier, France
Carlos Granell, Universitat Jaume I of Castellón, Spain
Samer Hassan, Universidad Complutense de Madrid, Spain

Copyright Information

Table of Contents

Time, Occurence and Switching

Appropriation of two tools in collaborative design
Point of view of aspectualization

Samia Ben Rajeb
Université Libre de Bruxelles
Brussels, Belgium
email: samia.ben.rajeb@ulb.ac.be

Shima Shirkhodaei
University of Liege
Liege, Belgium
shima.shirkhodaei@ulg.ac.be

Pierre Leclercq
University of Liege
Liege, Belgium
pierre.leclercq@ulg.ac.be

***Abstract*— This article focuses on the modes of implementation of an innovative device, associating two tools to instrument distant and synchronic collaborative design. The paper presents results about the modes of implementation of an innovative device, which combines two tools, in order to instrument distant and synchronous collaborative design. On account of the fact that these tools differ essentially in terms of immersive and non-immersive work space, this research focuses initially on modes of switching, which are used in an immersive work space to a non-immersive work space. Our work questions the appropriation of the two tools by users, relying on looks, designs, but also the collective operations involved in the design process.**

Keywords- computer supported cooperative work; methodology of multi-modal user interfaces analysis; semiotics; cognitive ergonomics; case study of collaborative synchronic design platforms.

I. INTRODUCTION

The rapid evolution of operating technologies in the field of collaborative design raises not only the question of the singular use of each tool, but also the influence of their association in this activity and during the action. In this context, we present here an analysis of the modes of appropriation of an innovative device, associating two tools to instrument distant and synchronic collaborative design : the Hybrid Ideation Space (HIS), developed at the Hybridlab, a laboratory of University of Montreal [1][2], and the Sketch Sharing system (SketSha), developed at LUCID, a laboratory of University of Liege [3][4]. Both are based on the notation of graphic artifacts in real time. One (HIS) allows immersion in the interior of a virtual representation of a conceived space, the other (SketSha) makes it possible to share and act on 2D documents. In the experiment, these two tools were associated to allow two groups of student designers from University de Liege and School of Architecture of Nancy to collaborate, under the direction of the HybridLab team. Two questions emerge from this original experimental situation: the first concerns the singular implementation of each tool and the second concerns the degree of programmatic compatibility in the use of a device, which integrates various tools for exchange and synchronic collaboration. To answer these questions, Section II first describes the experimental protocol implemented in the simultaneous usage of these two tools. In Sections III and IV, we present the methodology of data analysis based on the notion of aspectuality (punctual, iterative, durative, inchoative and terminative), well known in the field of Greimasian Semiotics. This notion guides us to the definition of determining categories to explain the switching from one tool to the other during the collaborative activity.

Our approach focuses on the methodological aspect to enable the analysis of complex collective activities involving new technologies. This is why our state of art only concerns the methods and shows why we have resorted to aspectuality to address this kind of problem (see Section III).

Based on quantitative and qualitative analyses, Section V will show that the degree of familiarization of users with the new technologies is a determining factor to characterize the issues and the limits of this superposition of tools. Finally, we will also detail to what extent these two complementary devices can be articulated in order to support preliminary phases of architectural design.

II. FRAMEWORK AND RESEARCH QUESTIONS

This research is part of collaboration between the LUCID laboratory at the University of Liège and Hybridlab at the University of Montreal. Both HIS and SketSha devices, developed in in the universities of Liege (Belgium) and Montreal (Canada), were enabled to instrument collaborative design.

SketSha software enables real-time sharing of drawings and annotations, via a digital tablet horizontally placed in front of the designer, drawn by using an electronic pen during a remote meeting. Images, PDF, DXF drawings or other documents can be imported and made available to all partners of the project. These documents are shared on the basis of a stack of semi-transparent tracing paper that users can annotate, store, superimpose or manipulate in real time.

HIS is a device based on an immersive system for placing various remote users within their graphic representation, their sketched freehand drawings and three-dimensional models "on which they interact by manual and digital actions". This complex device mainly consists of two parts: (1) a digital tablet placed horizontally showing a 2D image of the project. The image is chosen by the designer and depicts the localization of the project intervention. This image allows drawing and annotation via an electronic pen; (2) a piece of canvas that is hung vertically to close the work

 ISBN: 978-1-61208-575-3

space in which the designers act. The same image that is pre-treated to provide users with a 360 ° view of the inside the project can be projected on its surface. This projection helps designers immerse themselves in real time in their sketches while drawings appear on the tablet in front of them.

An experiment involving these two devices to design a project was set up. Two groups of designer (students of University of Liege and the School of Architecture of Nancy), who were geographically distant, worked for about 3 hours. The synchronous use of HIS and SketSha at this collaborative meeting involved two virtual work spaces that share a resembling feature, namely the sharing of graphic documents in real time on the digital table between the users taking part in the meeting from two geographically distant offices. However, these two devices are distinguished by the HIS-device's immersive dimension. Therefore, our first research question relates to the activity of actors in each work space called (Work HIS and Work SketSha).

Thus, we will study the "duration" and "occurrence" of the two main activities of actors were studied, namely designing and being able to look in both work spaces. Our second research question concerns the modes of switching from one work space to another. Our hypothesis is based on the existence of two types of switching used by the actors: (1) switching between Work HIS and Work SketSha, (2) switching between 2D and 3D.

It should be noted that although the HIS requires physical precedence of some immersive space throughout the meeting, the mode of the presence of the immersive space for the meeting depended primarily on the activities of users and how they made this immersive space (from 2D to 3D) real. On the other hand, it was necessary to compare these remarks with collective operations involved in this collaborative architectural design. This parallelism enabled us to notice the specific particularity of time used for each tool during a collaborative session. Once we determined the decisive moments of the two types of switching, we noticed the specificity of these changeovers and then analyzed them from the point of view of the aspectualization defined in the field of linguistics and semiotics.

III. METHODOLOGICAL POSITION

The question that we pose is: how can the ideas related to the notion of aspectuality help us describe the complex collective activities and enable us to specify the methods of changing from one immersive work space to another work space? In fact, other scientific fields have taken an interest in the analysis of collective activities. For example, in sociology, the question has been asked in terms of the organization of actors' roles in a team [5], or in terms of recognition, personal satisfaction and confidence among the different members of a team [6]. In cognitive ergonomics, the questions are centered on the interactions between partners, on the synchronization of the collective activity of design and on the cognitive aspects [7]. When the activities involve new technologies, one finds oneself in the scientific fields of CSCW (computer supported cooperative work). Moreover there are different points of view to analyze this kind of complex activity [8][9][10] :

1) The point of view of the physical aspects of the work: this point of view is only interested in the ergonomic and physical aspect of the space in which the designer works. We speak of the physical space with its acoustic and thermal properties, gestuality, movements, postures, etc.

2) The point of view of the affect is concerned with the psychological or emotional aspects of the designers. This aspect measures the subjective feelings of the designers in relation to their surroundings and their collaborator. Thus, it deals with hierarchical relations and feelings of confidence that unite the different members of a team ;

3) The cognitive point of view looks at the cognitive aspects of the design process that are linked to the situation, the actors and the subject in question. In this case, the conscience of the group, the intermediary objects and the shared reference are parameters to be considered to study these situations ;

4) The organizational point of view's objective is to define the modalities of assistance to the situations of group work or to help inmanaging group-design documents.

Our paper proposes another point of view which tackles the collaborative design activity involving new technologies: semiotics. The reference to the notion of aspectuality in linguistics and in Greimasian semiotics [11][12] helps us to address the question of the appropriation of the two tools SketSha and HIS, considering time, occurrence and switching. The definition of Holt 13], p. 6, is one of the first attempts to define aspect. According to Holt, aspect concerns "different ways of conceiving the flow of process". The nucleus of this definition remains unchanged. The notion of aspect is currently used in linguistics as a grammatical category that expresses the subject representation of a process denoted by a verb [14] p. 53. Thus, a verb, an adjective or a noun can be analyzed in terms of aspectualization. For example negotiation or decision-making are aspectualized substantives, insofar as the first is considered as an unfinished act and the second as an act already completed. For Bertrand [15], "aspect modulates the semantic content of the predicate, whether it is in past, present or future". Via this notion of aspectuality it is possible, for example, to address the issue of the progress of a process otherwise than by time. For example, if the aspect is taken in terms of time, it is called "punctual" or "durative". The aspect can be described as "terminative" when it is approached from the point of view of its completion and "inchoate" when it is intended to be the beginning. Here, the process is not only related to time but also concerning the state of its switching (see Section V Results).

This specification in the synchronous use of two tools, supporting collaborative design in an architectural design project, led to the issue of proportion via the aspectuality relative to time, occurrence and switching.

Our methodology is therefore based on this concept of aspectuality with the aim of analyzing quantitatively and qualitatively complementary data from this experiment. A coding scheme was defined for the transcription of a user's activities before the semiotic analysis of the processed data.

In concrete terms, it is a matter of leaning of the three fundamental to elements of aspectuality (time, occurrence,

 ISBN: 978-1-61208-575-3

and switching) to analyze the method of appropriation of the system and to evaluate more precisely the stakes, the limits and the perspectives of each single modality ("drawing" and "looking") and complex ("collective operations of design) during the use of these two tools. Thus an adjustment practice was put forward including speech, drawings and looks. The manners in which the two tools were specified have been appropriated by the different participants / designers.

Before going directly to the presentation of the results, we propose to clarify the context and the protocol of this experiment. Protocol description: the technical device and information processing of experiment. Our protocol is part of a framework defined by different factors: diversity of participants in the experiment, problematic addressed during the design exercise and graphical elements, which were available and shared between the actors.

IV. PROTOCOL DESCRIPTION: THE TECHNICAL DEVICE AND INFORMATION PROCESSING OF EXPERIMENT

Our protocol was part of a framework defined by different factors: the diversity of the participants in the experiment, the problematic addressed during the design exercise and graphical elements, which were available to and shared between the actors.

A. User List (A1, A2, A3, B1, B2, B3, B4, C) and problematic addressed

Three user groups participated in the collaborative session that was analyzed. In Liege, an architecture teacher and two students enrolled in Master Engineer Architecture took part in the project (A1, A2, and A3). In Metz, an architecture teacher, a Psycho-Ergo teacher and two Master students of Architecture from Nancy were connected (B1, B2, B3, B4). The third group, namely the observer team and moderator of the session, communicated from Montreal and represented the client for the project (C). The presence of this group was reassuring from the perspective between the organization of the experiment. An incident caused by a problem of incompatibility between two versions of Skype delayed the launch of the session because of the lack of sound. The fast and effective intervention of the third group succeeded in solving the problem (SketSha was able to communicate by graphic tracks to explain the dysfunction of the sound). All groups shared real-time graphical annotations and exchanged information orally via videoconference.

The problem set for the two teams consisted of reorganizing an existing library. The participants were invited to think about possible and future uses of the existing spaces of the library in order to suggest a reorganization better adapted to contemporary uses and new TIC technologies. They spontaneously focused on a windowed space at the back of the library that offers a view of the surrounding wooded landscape.

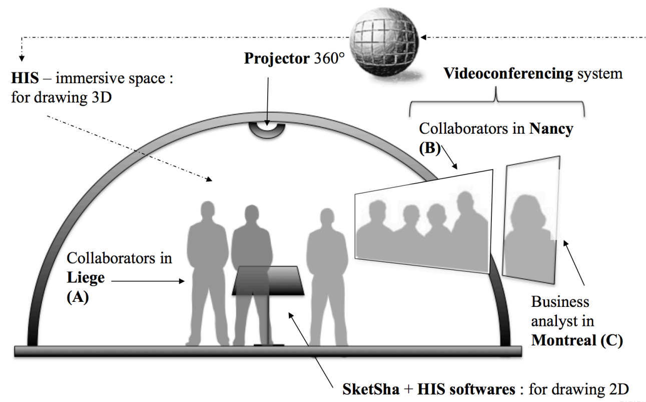


Figure 1. Context of experiment

B. Graphical elements shared on the HIS and SketSha

Students' work focuses on graphical documents existing on SketSha and pictures taken inside the library and prepared to be displayed on the HIS. On SketSha, 3 documents were shared: (1) a floor plan of the existing building with furniture; (2) a floor plan of the existing building without furniture; (3) a view of the property and the insertion of building onto the site. On HIS, different views in human scale were projected in the immersive, manipulated, and annotated space (see Figure 1).

C. Data processing and coding scheme

- SketSha Replay, software designed and developed by LUCID to code a recorded video from a collaborative session according to exclusive criteria. In our case, these criteria were defined according to the three activities (draw, watch, and work together") with the aim of identifying the actions of users in both immersive and non-immersive workspaces.
- List of criteria for coding, criteria that were selected emerged from two types of categories: simple and complex. The first took into account the individual intervention of users in the shared graphic space; the second was derived from the collective activity of each of these two groups.

D. Sequencing coding

Two types of sequencing coding were used that correspond to 1) sequencing at different times that made up the design process (Sequences 1-5); 2) sequencing according to the used tool (Work HIS, SketSha Work, Logistics or Bug).

E. Sequencing of process

- Seq. 1 – the request: the business analyst (c) exposed here his (her) request and all the other actors attempted to understand the objective aimed at by this new project;
- Seq.2 – the state of affairs: different teams exchanged several images of the existing library to understand how the current spaces were experienced and perceived;

- Seq.3 – the challenge of the existing library: after several discussions, two teams of designers decided to increase the space dedicated to reading, considering that this was the first priority for the development of the future library;
- Seq.4 – ICT adapted to the library: designers tried to incorporate new technologies that would be more appropriate for the future library;
- Seq.5 – challenging: the designers brought all current library programs into question and tried to answer this question: "What function to give to future library "?

F. Sequencing according to the used tool

This coding was done according to the work spaces used by actors during the process. We followed verbalization and the intention expressed by actors as they were asked explicitly to change the work space to validate a point of view. (Ex. "Can we switch to the HIS"). We proposed this coding for the entire duration of the collaborative meeting with the aim of realizing all switching from one tool to another during the experiment, and this was perfectly consistent with the initial objectives.

- "HIS" work space: Here, actors used the HIS device (by drawing in 2D on the digital tablet placed in front of them and by looking at their interventions projected on the canvas with 3D printing) for the synchronous sharing of documents, discussion and evaluation of their proposals.
- "SkeSha" work space: Here, the actors used SketSha software (by drawing in 2D on the digital tablet placed in front of them) during the meeting.
- "Logistics": All the moments when the actors communicated to adjust logistic problems were coded as moments that belong to the logistics.
- "Bug": It is about technical and computing problems, which caused the interruption of the exchanges in communication between the actors.

G. Selecting a sequence (Targeted Coding)

To collect our quantitative data, we opted at first for coding that targeted a particular segment: that of the third sequence of collaborative activity between users. This segment, which lasted approximately 10 minutes had the characteristics to mark several switches between the two devices. To ensure the accuracy of the coding of this sequence and thereby reduce the errors of interpretation, we included in this segment the end of the sequence, which preceded it and the end of the one which followed it. Thus, on the temporal axis of the observed meeting, the segment handled according to our coding scheme starts at 0:52:10 and ends at 01:12 00. Nevertheless, in this paper only the data relating to the sequence 3 (from 0:52:10 to 1:12:00) were quantitatively analyzed to prevent interruption of the special results of switching made during this sequence.

H. Simple Category: drawing and watching

Drawing. This category involves three criteria:

- Drawing SketSha: actors draw on SketSha.
- Drawing HIS: either actors draw on the tablet (2D) or they draw on the immersive space (canvas gives a 3D effect).
- Not drawing: the players do not draw.

Looking. This category involves six criteria:

- Looking SketSha: actors look at and follow the documents on SketSha.
- Looking HIS 2D: actors look at documents on HIS 2D.
- Looking HIS 3D: actors look at the documents on the HIS in the immersive space.
- Looking Visio: the actors make contact with their partners in inter-teams by looking at the videoconference.
- Looking at the other in situ: actors see their partners in the same team.
- Unidentified looking: looks are not identified (e.g., out of sight for observer).

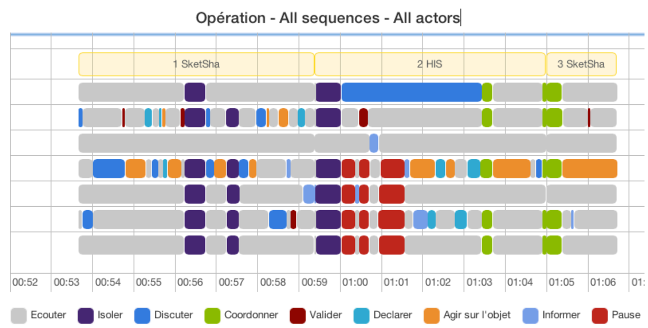


Figure 2. Timeline of Operation – All sequences – All actors

I. Category complex: collective operations of design

Processing of this category is to detect the different operations carried out by each of the actors working together. To do this, the analyses were based on the plots and words exchanged between the designers (see Figure 2). We have identified nine types of action [16]:

- Listening: this operation involves taking information from a program or other participants.
- Informing / sharing: This operation enables the designer to inform others and / or share their references, details of program or context.
- Declaring intentions or choices / raising a question: for this, the designer suggests and / or declares a new intention or question without trying to represent or to formalize it.
- Taking action on a subject: by this action, the designer formalizes his/her intention or ideas by graphic representation.
- Discussing / evaluating / questioning: this operation is reflected in the fact that an actor checks and/or discusses the proposals of another.

- Validating/ collective decision-making: it is to confirm or exclude an entire proposal related to the designed object.
- Isolating: This process occurs when a group is isolated from the other group, either by choice or by the bugs, and cuts the Internet.
- Coordinating / constructing the strategies of group: for this operation, the group is organized and / or sets up the meeting and / or tasks in order to work together, to validate group work strategies and / or to resolve disagreements between designers.
- Intent break: this operation is involved when one actor interrupts the discussion to say something, for example, to tell a joke.

V. RESULTS

The results presented in this paper only relate to the sequence 3 (increasing the space dedicated to reading), which was divided into sub-sequences considering the work space used, with the aim to observe more precisely and separately the appropriation of each tool (SketSha / HIS), and also to observe the changeover from one to another (1 SketSha / 2 HIS / SketSha 3). We relied on an index according to the verbalization in order to divide this sub-division into two moments of switching; A2: "could we switch to HIS?" B1: "Could we shift to SketSha?" (see Figure 3).

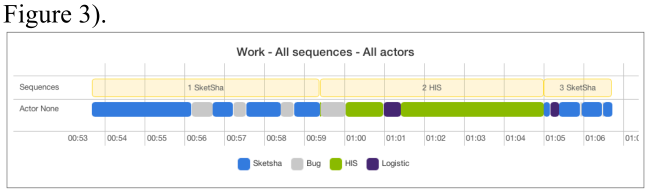


Figure 3. Progress of design according sequencing

Each Each of these sub-sequences was analyzed by using the proposed categories ("looking", "drawing" and "working together") with respect to the concept of "aspectuality." This concept allows a more accurate assessment of the issues, limitations and perspectives of each mode during the use of these two tools.

The time enables the measurement of duration of the act of looking, drawing and working together for each actor in his/her workspace. For example, depending on the relative length of the action, we distinguish two categories. The first is called “Punctual” when the designers decide to go from one tool to another. The second is related to actions that last such as when the designers discuss a problem related to the project being designed. This action is thus called “Durative”.

The occurrence allows us to measure how often an action took place during the design process. In reference to semiotics, if an action is repeated (in relation to another) in a rhythmic manner and more or less orderly in a specific workspace (Sketsha or HIS), the aspectuality of this action is qualified as “Repetitive”. For example, if each time an actor draws on the Sketsha tablet, the other actors look at the HIS canvas, there is repetition. If this repetition does not seem to correspond to a rule or logic, it will be qualified as being “iterative”. For example, it is not systematic if an actor picks up his pen and draws to discuss an idea or to suggest a solution.

There were also cases in which the action happens only once in a specific workspace. This occurrence that denotes "single" seems significant because it can highlight the manner that a user, with regard to the tools, can appropriate his/ her work environment.

Finally, switching enabled the analysis of the data qualitatively according to the time of passage from one workspace to another (SketSha > HIS / HIS > SketSha). With reference to semiotics, aspectuality of the action is described as "Inchoate" if the action is at the beginning of a workspace. But, the action is called "Terminative" if it takes place around the end of the workspace.

So, we rely on the three elements (time, occurrence and switching) to analyze the mode of appropriation of these tools.

A. *Appropriation of "duplicate" and "distinctive" practices according to the time and occurrence*

In this part, we distinguish duplicate practices from distinctive practices in the concept of appropriation. According to a common functionality permitted by SketSha as well as by HIS (synchronous sharing and remote graphical annotations via a tablet), actors can work together by passing from a 2D representation to an immersive representation in order to collectively design the architectural project.

The duplicate practice corresponds to the use of this common functionality between two tools. But, the distinctive practice is the use of an additional functionality. For example, the HIS also allows the use of immersive space via the 360° projector on the canvas surrounding the actors. But this immersion function is not permitted via Sketsha.

The appropriation of the use of a device combining these two systems presupposes an adjustive practice, which is halfway between duplicate practice and distinctive practice. To better understand the implications of this adjustive practice, our concern extends to the drawings, looks and words, as well as to collective operations involved in the context of architectural design activity. It must be remembered that in this experiment the actors are all invited to design a futuristic library where the need of improvement and increase of space is raised.

B. *Word exchanging, drawing and looking*

Since there is only one pen for each team, actors in the same team cannot draw at the same time on the same workspace. However, the partner who does not have a pen can "show" items on the shared tablet, he/she can "look" and comment on the projected images on immersive space and can "discuss" with all the others. As the action of "drawing" can be combined with other actions such as "looking", "showing" and "discussing", it cannot be involved except (1) in the HIS work space, (2) in the Sketsha work space. The actors can never draw simultaneously in both HIS and Sketsha workspaces. From the perspective of occurrence, the act of drawing is considered single in a workspace. But it is important to note that throughout the process, the act of drawing in Sketsha (about 10 %) is double compared to that performed on the HIS (about 5 %). The rest (85%) of the actions, which are considered as "not drawing", 1/6 of the design process in this sequence is dedicated to words and discussions between participants that are not represented graphically. Nevertheless, it becomes iterative at the end of process because when more designers advance in their choices, the percentage that is dedicated to drawing increases too.

From the point of view of time, drawing in a punctual manner corresponds to the plans' zoning. This enables actors to show zones that relate to the discussion about the project. By this action, they focus their discussions on shared graphics and make sure that all participants share the same "common ground" [17]. The act of drawing is durational when it comes to act on the subject or to discuss and evaluate potential opportunities and eventual choices for the project. By sharing this chart, they shape their discussions and synchronize cognitively the proposals of each other [18]. Therefore, drawing is done by punctual actions as well as by durative actions in both HIS and Sketsha workspaces. The punctual drawings play a demonstrative role while durative designs play an explanatory and / or argumentative role.

On the other hand, in the sequence studied, an adjustive practice specific to words, drawing and looking drew our attention. Certainly, realization of ideas happens mainly through statement and discussion between the actors because the words are meaningful, insofar as they provide elements to specify how actors contribute to the progress of the collective design. However, by comparing the action of "speaking" with "drawing", considering the time, "drawing" becomes a punctual adjustive practice during the conversations in order to clarify and explain an idea. Furthermore, aspectuality of action (durative for speaking and punctual for drawing) could be significant when combined with the activity and the space in which it operates. Indeed, it is necessary to understand how the use of a functionality of a specific tool seems relevant or not at a specific time of collective design. The proof is the example of a designer who asked first to switch from SketSha to HIS (immersive space) because of a disagreement about the quality of light on shelves. This was then followed by a new switching when another designer requested to switch back to SketSha in order to graphically show a point that needed to be developed.

"Looking" is considered as punctual action in some cases and durative in other ones. In both work spaces, watching videoconference and looking the other participants in situ are relatively punctual actions (considering the time) but also repetitive (considering the occurrence). In HIS, we found fewer effects of going back and forth between videoconferencing and the image projected on the canvas (3D) or the one that is produced on HIS 2D tablet.

It seems that actors focus more on their annotations and graphical elements shared and produced on tablet rather than expressions of their remote partners in video conferencing or in immersive space. In occurrence, more than 3/4 of looks are directed to the workspace for the annotation in 2D. For example, "watching a videoconference" only makes participants sure about the presence of the other or about the interest of the others in conversation or the reactions of others to what has been proposed. In this case "looking at the other one who is in situ" is significant. The actors look at the others in a punctual manner (in time) but repetitive (in occurrence). " When I look at the other one, it puts my mind at rest and then I go back to my job," said one participant.

Furthermore, the action of "looking" becomes durative when one of the designers acts on the subject by using the system of SketSha for annotation. In this case, all participants look continually in the direction of the tablet. Some also look at the picture projected on the canvas. However, when actors use only the HIS system, the one who is drawing looks rarely at the canvas (HIS 3D). He/she focuses mostly on the tablet (HIS 2D). At the same time, other users look only at the canvas on which the produced sketch is projected in 360 degrees.

"Looking at the immersive space" is involved in a punctual manner (when it comes to check punctually the validity of a choice of 2D in 3D space) and in a durative manner (when it comes to test a choice in 3D space). In terms of occurrence, this involvement is nevertheless iterative and non-repetitive as designers look at the immersive space according to their needs and the project's progress without any apparent or pre-decided logic.

C. Specificity of *collective* design

"Evaluating", "validating", "informing" and "declaring" appear to be punctually involved in the process, while other operations (such as "listening", "discussing" and "acting on the subject") are rather durative. Furthermore, it is important to note that the actors never tried to isolate themselves deliberately. Sometimes punctual and sometimes durative, this operation is more related to bugs caused by a network outage or disconnection of videoconferencing. However, almost all of these bugs were consistently tracked by re-questioning (via the "discussing" operation). Sometimes, they caused conflict, which, according to the users, would not have existed if the communication had been continued. Indeed, the actor interrupted by a bug is obliged to re-state what has been said before, and this sometimes causes tensions between groups.

"Isolating", "pausing" and "coordinating" operations are durative (considering the time) and iterative (considering the occurrence). They are involved here as part of the group's organization and work on several subjects for designing.

"Informing" is a punctual action whose occurrence is single in the third division in workspace (3. SketSha) while it operates iteratively in the first two divisions (1. SketSha and 2.HIS). This may be related to the project development and the mastery of problem by designers when the need for information sharing becomes less and less necessary but the action on the subject gains more importance at the end of process.

"Acting on the subject" is not only a durative operation, but also iterative because it does not follow any rule and can occur several times during the discussion.

"Validating" is punctual and repetitive because it is preceded every time by a discussion.

"Discussing" is a durative operation (by time) and iterative (by occurrence). If the operation involves a disagreement, it usually induces the request for switching from a workspace to another.

D. Appropriation relative to the time and the occurrence of the process

Based on quantitative data from codings, we correlated, in entire process, the specificity of time and occurrence of three categories: "looking" (in Figure 4), "drawing" (in Figure 5) and "working together" (in Figure 6). These three schemes summarize the correlations for the whole process. This correlation can chart the actions and operations using both types of aspectuality; one relating to the time and the other to the occurrence.

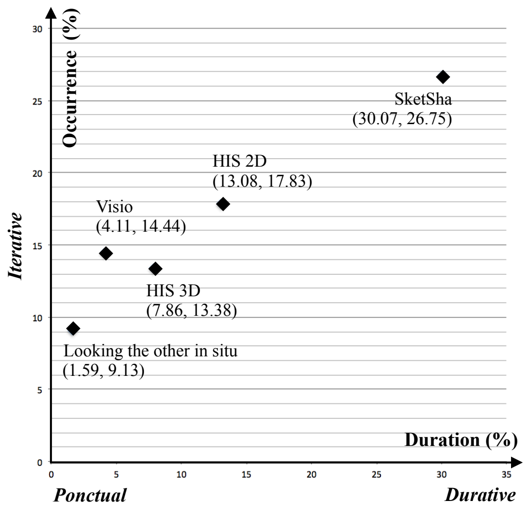


Figure 4. Correlation time/occurrence for " looking " (%).

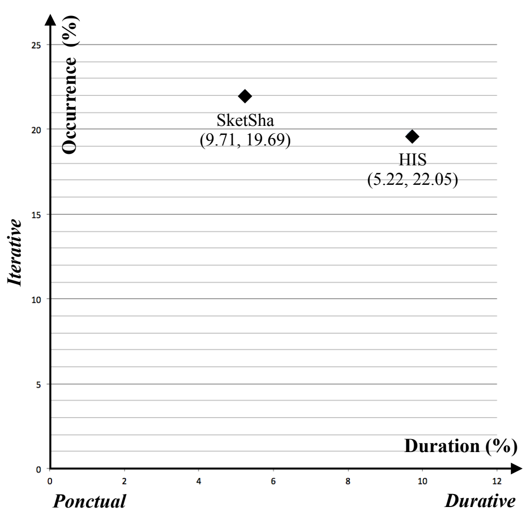
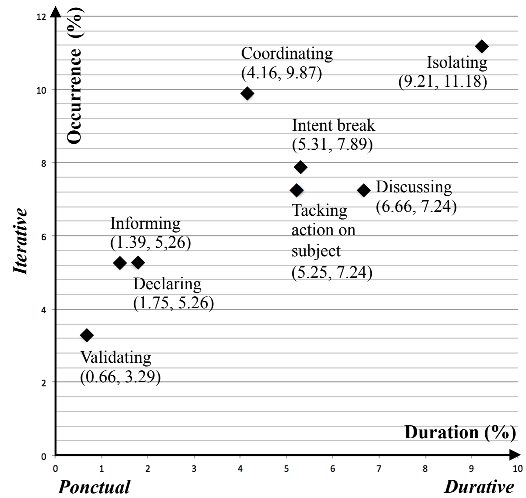


Figure 5. Correlation time/occurrence for " drawing " (%).

Returning to the aspectuality of actions of each of the three sub- sequences in each workspace (see Appropriation of a "duplicate" and "distinctive" practice according to the time and occurrence) we deduced identical results.



	Validating	Informing	Declaring	Coordi-nating	Taking action	Intent break	Discussing	Isolating	Listening
% Duration	0,66	1,39	1,75	4,16	5,25	5,3	6,66	9,21	65,61
% Occurence	3,29	5,26	5,26	9,87	7,24	7,89	7,24	11,18	42,76

Figure 6. Correlation time/occurrence for " Collective operation for design " (%).

The parallelism between these results and those put forward by charts shows that the actors appropriately duplicate practice in the same way in HIS and SketSha.

However, this parallelism is not easy concerning the distinctive practice. Indeed, we note that aspectuality is not the same from one workspace to another. If the actors refer in a punctual manner to the immersive space when they act in SketSha, they look for a long time at immersive space when switching their work to HIS.

This contrast can be explained by the degree of conformity between the functions basically provided by each tool (during their development) and uses that designers make (after combination of two tools in this experiment). The actors seem to adopt an adjustive practice (a practice between duplicate and distinctive) that seems to be in accordance with the potential of the tool and the manner it is set up by the user.

E. Appropriation of a collective practice of switching from one tool to another

To better understand the modes of switching from one workspace to another, we refer to the aspectuality called inchoate or terminative in this context (see Figure 3).

Qualitative analysis shows that the terminative aspect is related here to the discussion. In fact whenever there is: (1) Either a disagreement between actors about a proposal by one of them (2) Or uncertain understanding of participants about a new choice announced, designers suggest switching to another work space (from SketSha to HIS and HIS to SketSha). In this experimental context, the terminative element is imprecision and disagreement. As long as switching from HIS to SketSha is a way to check what was decided in the immersive space, actors have the opportunity to look at the same time at the canvas where annotations previously made in 3D by HIS are projected and at the tablet exposing documents and new annotations made on SketSha.

 ISBN: 978-1-61208-575-3

So, actors can easily compare their choices for workspace. In this case, the designers are in a distinctive practice. The converse is not correct because during the switching from SketSha to HIS, the workspace for the first one disappears from the display on the tablet, and leaves the interface to the HIS workspace. The designer draws on the tablet (HIS 2D) while the other participants look at the annotation performed in the immersive space of the canvas (HIS 3D). In this second switching, designers are in a duplicate practice.

Considering therefore the operations of "challenging" the actions performed on the object and "statement" of new proposals as terminative elements in the process of switching from one work space to another, the validation becomes an inchoate element in the process. This element marks the beginning of each switching in the use of a tool. This operation is then followed by several operations that enable the users to act on the object to be designed.

An iterative process between questioning, validation and acting on the object continues throughout the work of designers while the use of a particular tool plays a predominant role in making decisions. Indeed, even if two systems originally offer the same function for real-time and remote sharing of graphical annotations, their specificity (immersive space / non-immersive space) suggest another perspective on the object to be designed. This specificity provides a new workspace, negotiation and consensus-building between participants and allows them to test and validate their choices.

VI. CONCLUSION

Contribution. Our research concerned the modes of appropriation of an innovative collaborative platform, to instrument distant and synchronic design by associating two tools, which support artifact annotation in real time.

This work allowed us to develop an analytical method that uses concepts related to semiotics in order to observe systemically the collective activity of design using various tools at the same time. In fact, through our data analysis and by using this method at the border of the fields of cognitive ergonomics and semiotics, we could clearly identify the use of 2D, the use of 3D and switching from one to another. In other words, what makes an actor switch from one to another? The observation of this practice that is at once "duplicate" and "distinctive" showed that look, drawing, and word (representing "working together") play an important role.

It is obviously possible to draw in a tool and look simultaneously at another workspace, and this was observed during the use of SketSha (2D plans on tablet produced parallel to the interior image of library, which was projected in the immersive space. In this case, it was not a switching from one tool to the other but an oversizing of the workspace. The activity was not just in 2D or 3D, but it was oversized to offer two different perspectives simultaneously for a single area of the designed object. Even when actors worked in space dedicated to SketSha, they occasionally referred to the immersive space. However, in the context of use of the HIS device, the interface of HIS 2D appearing on the tablet involves systematically the disappearance of the SketSha workspace. A definite switching from one activity on a tool to a new activity on another tool is marked.

Moreover, aspectuality related to switching of certain collective operations shows the effectiveness of the combination of two tools in order to validate the collective choice in the collective and remote design of a project. In both cases of switching (1) from SketSha to the HIS and (2) from HIS to SketSha, appropriation of a tool's specific functionality allows designers to better understand the ideas expressed, to build a common ground and to move forward together in a preliminary design phase. Nevertheless, the recurrent problem of bugs and sound dropping during the videoconferencing due to network disconnection did not help to build awareness among participants. This even caused some conflict between them. Both findings highlight the notions of completion and accomplishment throughout a permanent evaluation of ideas in the process. If all the operations that we have emphasized are essential in these early stages, it would still be considered a privileged place for punctual operations such as "informing", "declaring" or "validating together" which require good functionality of the tool.

Limitations. Focusing on the modes of simultaneous appropriation of these two tools for collaborative design, this research is certainly not intended to be generalizable to other cases of tool and device combination. Nevertheless, the method implemented for processing and analysis of this type of combination is still interesting because it combines quantitative and qualitative data in a systematic, repeatable and disciplined approach. To further this approach and prove its validity, it is necessary to confront other contexts of using combined tools by exploiting the concepts from the field of semiotics.

In addition, semi-structured interviews were conducted as part of this experiment, but these data were only used partially in our analysis.

The in-depth processing of designers' feedback will enable the issue of aspectuality to be addressed in greater detail from the users' perspective by reference to how they describe their experiences of appropriation of combined tools.

Prospects. We plan to apply our approach (1) on one hand in longitudinal observations to analyze the evolution of this appropriation process in time and (2) on the other hand, to observe new collective activities such as participative production of a same artwork from distance.

REFERENCES

[1] T. Dorta, Y. Kalay, A. Lesage, and P. Pérez, "Design conversations in the interconnected HIS", in Carrara G., Fioravanti A., Trento A. (eds.), Connecting Brains Shaping the World : Collaborative Design Spaces, EuropIA 13, Rome, pp. 83-94, 2011.

[2] http://www.hybridlab.umontreal.ca/his.php?l=fr, last access in April 2017.

[3] S. Ben Rajeb and P. Leclercq, "Using Spatial Augmented Reality in Synchronous Collaborative Design", Yuhua Luo éd., In Lecture Notes in Computer Sciences, Springer, vol 8091, pp. 1-10, 2013.

[4] http://www.sketsha.be/F11_Innovation.html, last access in May 2017.

[5] J. G. Breslin, "Social Semantic Information Spaces", in Semantic Digital Libraries, pp. 55-70, 2008.

[6] M. Lourel, S. Abdellaoui, S. Chevaleyre, M. Paltrier, and K. Gana. "Relationships between psychological job demands, job control and burnout among Firefighters", in North American Journal of Psychology, 10(3), 489-496, 2008.

[7] F. Darses, M. Wolff. "How do designers represent to themselves the users' needs?", in Applied Ergonomics, 37 (6), pp. 757-764, 2006.

[8] J. F. Boujut, P. Laureillard, "A co-operation framework for product process integration in engineering design", in Design Studies, 23 (5), pp. 497-513, 2002.

[9] P. Carlile, "Transferring, translating and transforming: an integrative framework for managing knowledge across boundaries", in Organization Science, 15, pp. 555-568, 2004.

[10] J. M. Carroll, D. C. Neale, P. L. Isenhour, M. B. Rosson, and D. S. McCrickard, "Notification and awareness: synchronizing task-oriented collaborative activity", in International Journal Of Human-Computer Studies, 58, pp. 605-632, 2003.

[11] A. J. Greimas and J. Courtés, Sémiotique. Dictionnaire raisonné de la théorie du langage, (translated by "Semiotic. Dictionary of the Language Theory"), Paris, Hachette, 1993.

[12] J. Fontanille, Le discours aspectualisé, PULIM, Limoges, 1991.

[13] J. Holt, Etude d'aspect. (translated by "Aspect studies"), Acte Julandicia. 15 : 2 Copenhague, 1942.

[14] J. Dubois and al., Grand Dictionnaire de linguistique et des sciences du langage, (translated by "Dictionary of Linguistics and Language Science"), Paris, Larousse, 2007.

[15] D. Bertrand, Précis de sémiotique littéraire (translated by "Literary semiotics"), Paris, HER, 2000.

[16] S. Ben Rajeb S., "Conception collaborative distante : étude architecturologique pour la caractérisation des opérations cognitives" (translated by "Remote collaborative design : architecturology analysis to specify cognitives design operations"), V. Angenot, S. Safin, M.G. Dondero & P. Leclercq éd., In Interfaces numériques : Collaborer à distance, enjeux et impacts des interfaces numériques dans les pratiques collaboratives synchrone, Lavoisier, 2 – n°3, pp. 509-530, 2013.

[17] J. Beers Pieter, H. P. Boshuizen, P. A. Kirschner, and W. H. Gijselaers, "The analysis of negotiation of common ground in CSCL ". Learning and instruction , vol. 17, n°4, p. 427-435, 2007.

[18] F. Darses, A. Mayeur, C. Elsen, C., and P. Leclercq, "Is there anything to expect from 3D views in sketching support tools?". Gero, J., Goel, A. (eds.) Design Computing and Cognition 2008: Proceedings of the Third International Conference on Design Computing and Cognition , Atlanta, USA, pp. 283–302. Springer, 2008.

Ensuring Correctness of Agent Interactions in Collaborative Environments

Elena Troubitsyna
Åbo Akademi University, Faculty of Science and Engineering
Domkyrkotorget 3, 20500,
Turku, Finland
e-mail: Elena.Troubitsyna@abo.fi

***Abstract*— Ensuring correctness of agent interactions in complex systems constitutes a significant research challenge. The highly dynamic nature of the system makes it hard to predict all possible collaborations that the agents form during the system functioning. Therefore, it is desirable to create a generic abstract model that can facilitate reasoning about correctness of agent interactions in the complex dynamic collaborative environments. In this paper, we adopt a goal-oriented approach to reasoning about agent collaboration and define the basic abstractions underlying the behaviour of complex collaborative systems. Each agent has individual capabilities that are complemented and enhanced via cooperation to allow the system to achieve the desired goals. We define an abstract model of a system whose behaviour can be structured as a set of dynamic coalitions. We propose a structured approach to analysing possible deviations in the component interactions based on Hazard and Operability Study (HAZOP) and formally define the impact of deviations in agent interactions on achieving the required goals.**

Keywords -dynamic coalitions; interactions; goals; deviation analysis; formal modelling.

I. Introduction

Over the recent years, creating new services and applications via collaboration has gained a significant popularity. Dynamic collaborations and compositions of agent components allow the designers to achieve agility and high productivity in the development of new features and functions. Dynamic collaboration is in the heart of such major trends as the Internet of Things [10], industrial internet and Internet of Everything. These concepts are built on the pervasive connectivity and openness towards sensors, machines and devices. The opportunities offered by dynamically composed collaborative environments offer rich technical and business opportunities that can be efficiently utilised to dynamically create novel flexible architectures.

The highly dynamic nature of collaborations requires novel approaches that allow the designers to systematically analyse the dynamics of collaborative environments and in particular, predict how deviations in the agent behaviour and interactions impact the functions that a collaborative environment should implement.

Currently, it has been commonly accepted that the notion of goals provides us with a suitable basis for formalising the objectives that a system should achieve [4]. The agents form coalitions to interactively work on achieving certain goals. The agents forming collaboration provide certain individual functionality that contributes to achieving a common goal. When an agent or a communication infrastructure fails, a coalition might fail to achieve the desired goal. Therefore, we should systematically explore the possible deviations in the agent and communication infrastructure behaviour and study the impact of these deviations on the possibility of achieving the required goals.

In this paper, we demonstrate how to use the HAZOP method [1][2] to systematically study possible deviations in the agent interactions. We propose a classification of the types of deviations in the agent interactions and define their impact on achieving system goals.

We define a generic model that formalises the relationships between the system goals and possible deviations in agent behaviour and interactions. Since the proposed model explicitly links the system goals with the behaviour of the individual agents in a coalition, it can facilitate design of complex collaborative systems.

The paper is structured as follows. In Section II, we define collaborative environments in terms of the goals that should be achieved by agent coalitions. In Section III, we describe generic scenarios of agent interactions. Section IV shows how to systematically analyse deviations in the component interactions using HAZOP. Finally, in Section V, we discuss the proposed approach and overview the related work.

II. Towards Formal modelling of Collaborative Environments

In this paper, we define a *collaborative environment* as a set of coalitions, i.e.,

$$ColENV = \{C_1, C_2, ..., C_N\}$$

where Ci is an id of a coalition.

A coalition is a dynamic composition of the agents. The agents join and leave a coalition depending on their states and the current goal. As soon as an agent joins a coalition, it can communicate and collaborate with all the agents involved into it. In general, any coalition is formed to fulfil a certain goal [4]. The set of goals, which an entire collaborative environment can achieve, is denoted as *GOALS:*

$$GOALS = \{G_1, G_2, ..., G_M\}$$

The set consists of the constants defining the names of the goals. We assume that each particular coalition is formed to perform a certain goal from the set *GOALS*.

A *goal* is an objective that a coalition should achieve. A goal can be decomposed into a set of subgoals, and furthermore, into a set of sub-subgoals that each component in the collaboration should perform. Each agent carries a special attribute describing the functionality that it implements. Often these attributes are called roles. Usually, an agent implements a set of roles chosen according to the tasks that it should perform in each particular coalition.

For each coalition, we can define a configuration function that indicates how many agents in certain roles a coalition should have for a goal to be achievable. Hence, a configuration can be defined as follows:

$$Config \in CONFIG, \text{ where } CONFIG : \mathcal{P}(ROLES \rightarrow N)$$

where *ROLES* is a set of roles, $\mathcal{P}$ denotes a powerset and *N* is a set of natural numbers.

Often a configuration of a coalition is defined not only by a goal but also non-functional parameters, e.g., performance. We assume that goals are distinct if their non-functional parameters are different. Therefore, we can unambiguously map a set of goals onto the set of configurations.

For each goal *Gi*, $Gi \in GOALS$, we can define the minimal sufficient configuration as a function

$$MINCONF : GOALS \rightarrow CONFIG$$

The function defines how many agents in each role a coalition should have to be able to achieve a certain goal. The function *MINCONF* defines the minimal necessary conditions. Obviously, a coalition can have more agents than required by *MINCONF*. The additional agents can remain inactive while achieving a certain goal and become activated to replace failed agents in case some of initially involved agents fail.

In practice, at each particular moment of time, a collaborative environment *ColENV* does not try to achieve all the goals defined by the set *GOALS* at once. Therefore, we can distinguish between a set of the active (triggered) goals *Act_G*, i.e., the goals that a collaborative environment tries to achieve at a certain moment of time and the goals that are not triggered, i.e., passive goals *Pas_G*,. This defines a partitioning of the set of goals into two non-intersecting subsets:

$$GOALS = Act\_G \cup Pas\_G,$$
$$\text{where } Act\_G \cap Pas\_G = \emptyset$$

In our modelling, we assume that the agents are not dormant and hence, they are getting engaged in the different coalitions (as soon as their roles match the roles required in the coalition. Therefore, when a goal is activated, it might take some time to fulfil the conditions defined by *MINCONF* because some of the required agents are still engaged in another coalitions. If the required configuration is established, then, the coalition executes the required actions to achieve the goal. We introduce a set

$$C\_STATE : \{Active, Activated, Dormant\}$$

to designate the status of the coalition. The constant *Active* means that the coalition has the required configuration and is assigned a goal to achieve. The constant *Activated* means that the coalition is assigned a goal but it has not established the required configuration. Correspondingly, the constant *Dormant* means that the configuration is currently not involved into an execution of any goal. We introduce the function *C_STATUS* that maps the id of the collaboration to its status:

$$C\_STATUS : CNAME \rightarrow C\_STATE$$

The function *CUR_CONFIG* is defined as follows:

$$CUR\_CONFIG : CNAME \rightarrow CONFIG$$

It designates the current configuration of the coalition.

Next, we formally define the relationships between the status of a coalition, goals and configurations.

The coalition *Ci* is active, i.e.,

$$C\_STATUS\ (Ci) = Active$$

if

$$Gj \in GOALS \wedge$$
$$Gj \in Act\_G \wedge$$
$$MINCONF(Gi) \leq CUR\_CONFIG(Ci)$$

where the ordering relation $\leq$ is defined over the configurations as follows:

For $Conf_k$ and $Conf_l$, such that $Conf_k$, $\mathrm{Conf_l} \in CONFIG$, $Conf_k \leq Conf_l$ if

$$\forall r_n . r_n \in dom(\mathrm{Conf_k}) \Leftrightarrow r_n \in dom(Conf_l)$$
$$\forall r_n . r_n \in dom(\mathrm{Conf_k}) \Leftrightarrow Conf_k(r_n) \leq Conf_l(r_n)$$

where *dom* denotes the domain of function or relation.

When a coalition *Ci* is set to achieve a certain goal but has not established the required configuration or an execution of a scenario required to achieve a goal is suspended due to failures, its status is *Activated, i.e.,*

$$C\_STATUS\ (Ci) = Activated$$

if

$$Gj \in GOALS \wedge$$
$$Gj \in Act\_G \wedge$$
$$\neg (MINCONF(Gi) \leq CUR\_CONFIG(Ci))$$

Finally, a coalition can be inactive, i.e.,

$$C\_STATUS\ (Ci) = Activated$$

if

$$Gj \in GOALS \wedge$$
$$Gj \in Pas\_G$$

We assume that agents are involved in the coalition with the status *ACTIVE* communicate with each other by exchanging messages. To achieve a certain goal, a coalition should perform a predefined scenario. In the next section, we define generic scenarios performed by the components in a coalition.

III. Modelling System Architecture and Agent Interactions

A goal defines a set of states that a collaborative environment should achieve. While working of achieving a certain goal, a coalition executes a certain scenario. An execution of a scenario is triggered by a coordinator of the coalition. It is an agent with the specific rights to initiate and finalise the scenario execution. We can describe a scenario by a UML [5] use case model and supplement it by a description of the flow of events associated with it. The actors of the use case model are the agent roles and the use cases are the coalitions achieving the corresponding goals. Due to the generic nature of our model, we omit its graphical representation. A description of typical and abnormal flows of events in a generic use case associated with our system can be defined as shown below:

Description of use case
Coalition Ci achieves goal Gj

Precondition *Goal is eligible for execution and triggered*

$$Gj \in GOALS \wedge$$
$$Gj \in Act\_G \wedge$$

Postcondition *Collaboration achieves goal or Collaboration reports failure*

Includes: *Recover_Scenario_Ci_Gj*

Normal sequence of events:

1. The coordinator of *Ci* receives a notification that a goal is activated and changes the status of the coalition, i.e.,

$$C\_STATUS\ (Ci) := Activated$$

2. The coordinator broadcasts an invitation to join a coalition to the agents of *ColENV* and monitors that the required configuration is established
3. When a configuration is established, i.e.,

$$MINCONF(Gi) \leq CUR\_CONFIG(Ci)$$

it broadcasts the message engaged to the involved components and changes the status of the collaboration, i.e.,

$$C\_STATUS\ (Ci) := Active$$

4. Agents collaborate and communicate with each other to perform the tasks required to achieve the required goal and the coordinator monitors the status of the agents in the duration of the scenario execution. If it discovers an agent failure then go to step 8.
5. When goal is achieved the agents report to the coordinator about completion of scenario.
6. Coordinator hands over the control to the collaborative environment manager and changes the status of the collaboration, i.e.,

$$C\_STATUS\ (Ci) := Dormant$$

7. The coordinator broadcasts disengage message to all agents.
8. The collaboration coordinator re-evaluates the status of the coalition. If the condition of the sufficient configuration is not satisfied then it changes the status of the collaboration to *Activated* and activates timer.
9. If the agents recover within the timeout then the status is changed to *Active* and the normal execution is resumed.
10. If the agents fail to recover within timeout then switch to executing failure recovery scenario *Recover_Scenario_Ci_Gj.*

Description of use case *Recover_Scenario_Ci_Gj*

Precondition
Normal execution of scenario to achieve goal Gj by coalition Ci failed.
Status of Ci is Activated

Postcondition Reconfiguration and resuming normal execution or permanent failure

Extends: *Coalition Ci achieves goal Gj*

Sequence of events:

1. The coordination of *Ci* broadcasts a new invitation to all agents of the collaborative environment to join a coalition and activates a timer
2. If within the timeout the coordinator receives a respond from the agents whose roles match the roles of failed agents then continue. Otherwise the scenario terminates, i.e., go to 4.
3. The coordinator sends engagement message to the newly joining agents and changes the status of the coalition to *Active*. After this, the normal execution

 ISBN: 978-1-61208-575-3

resumes, i.e., the use case *Collaboration Ci achieves goal Gj* resumes.

4. The coalition sends the failure message to the collaborative environment manager and changes the status of the collaboration *Ci* to *Dormant.*

5. The coordinator broadcasts disengage message to all agents.

Let us now depict the proposed system structure. We distinguish between three layers: the collaborative manager layer, coalition coordinators and, finally, agents. The structure is presented in Figure 1.

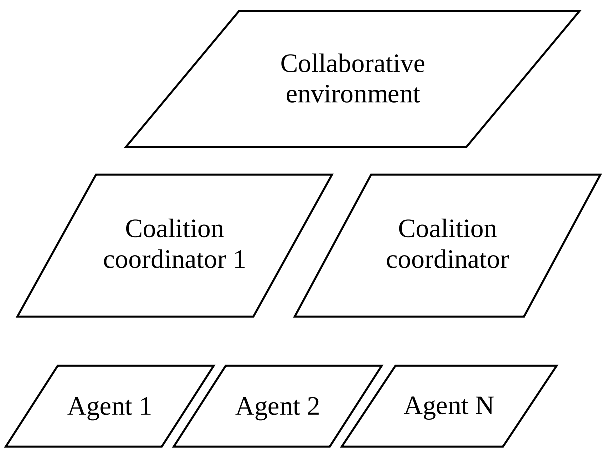


Figure 1. System architecture

The collaborative environment manager is responsible for triggering the system goals and broadcasting the corresponding messages to the coalition coordinators. The coalition coordinators (a special kind of agents) check whether they are eligible to initiate a coalition and if this is the case, broadcast the invitations to all agents of the collaborative environment. The coalition coordinator monitors the coalition forming and as soon as the configuration conditions are fulfilled, monitors an execution of the scenario associated with the given goal. Upon completion of the scenario, it acknowledges it to the collaborative environment manager and disengage the agents. If the execution of the scenario fails and cannot be recovered then the coalition coordinator reports the failure the coalition manager.

To join a coalition, each agent a check that it has the eligible role and becomes engaged in the coalition. If the resources permit then an agent can join several coalitions at the same time but typically in different roles.

As it is easy to note, the main complexity of ensuring correctness of agent collaboration is associated with handling agent failures and recovery. Indeed, it is easy to run into a deadlock situation, i.e., reach the state that no progress can be achieved because the agents are engaged in different coalitions and the system lack the resources to recover and resume its execution. Next, we discuss how to systematically analyse agent failure and ensure correctness of agent collaboration even in presence of failures using our analysis method, HAZOP, adapted for the analysis of the dynamic behaviour.

IV. Systematic Analysis of Correctness of Agent Collaboration

HAZOP – Hazard and Operability Study – is a well-established technique in safety analysis [1][2]. It was originally developed in chemical industry. HAZOP provides a group of safety experts with a structured basis for brainstorming possible deviations in the behaviour of the system and analysing their impact on safety. As a result of performing HAZOP, the safety experts typically identify hazards associated with the system and propose the means to mitigate them.

HAZOP defines a list of guideword that can be systematically applied to certain system parameters to identify whether the deviations in these parameters can cause safety hazards. The list of the guidewords is presented in Table I.

TABLE I. LIST OF GENERIC HAZOP GUIDE WORDS

Guideword	Interpretation
No/None	Complete negation of the design intention. No part of the intention is achieved and nothing else happens
More	Quantitative increase
Less	Qualitative increase
As Well As	All the design intentions is achieved together with additions
Part of	Only some of the design intention is achieved
Reverse	The logical opposite to design intention is achieved but something quite different happens
Early	Something happens earlier than expected relative to clock time
Late	Something happens later than expected relative to clock time
Before	Something happens before it is expected, relating to order of sequence
After	Something happens after it is expected, relating to order or sequence

Table I presents the generic guideword list from the Defence Standard 00-58 [1] and IEC-61882 [2]. Since the HAZOP method has been used in different domains, it has received several interpretations that allow the engineers to focus on a wide spectrum of aspects – from human errors to software.

To analyse the dynamic aspect of the system behaviour, we can interpret the guidewords in a variety of ways. While choosing the interpretation, we aim at understanding how the deviations in the agent behaviour and interactions in a coalition affect the likelihood of achieving the desired goals. In this paper, we adopt the reinterpretation of the HAZOP

 ISBN: 978-1-61208-575-3

guidewords proposed in [3]. The adopted interpretation of the HAZOP guidewords [3] focuses on the message exchange between the agents, as shown Table II.

Let us now explain how to apply the guidewords to the basic scenario of the agent interactions. We present the examples illustrating the situation in which the deviations in the agent behaviour result in a failure or a delay in achieving the desired goals.

Messages outgoing from the coordinator:

Invite message:
No: Execution of scenario is not triggered
Before: Message sent when the goal is not triggered
Earlier: Message sent before the goal is triggered
Later: Message sent with the delay

Messages from the agents:
Confirm participation
No: Message might block execution of the goal if no other agent confirm
After: Message delays execution of scenario

Inter-agent Communication Message:
No: No message is sent after completing execution: Deadlocks goal execution
More than: several messages sent after completing execution: scenario is executed in wrong order
Before /Early: message is sent before task completes and triggers earlier than required execution of tasks in another agents
Later: execution of the goal is delayed.

TABLE II. INTERPRETATION OF HAZOP GUIDE WORDS

Attribute	Guideword	Interpretation
Predecessor/ successors during interactions	No	Message is not sent
	Other than	Unexpected message sent
	As well as	Message is sent as well as another message
	More than	Message sent more often than intended
	Less than	Message sent is often as intended
	Before	Message sent before intended
	After	Message sent after intended
	Part of	Only a part of a set of messages is sent
	Reverse	Reverse order of expected messages
Message timing	As well as	Message sent at correct time and also incorrect time
	Early	Message sent earlier than intended time
	Later	Message sent later than intended time
Sender/ receiver objects	No	Message sent but never received by intended recipient
	Other than	Message sent to wrong recipient
	As well as	Message sent to correct recipient and also an incorrect recipient
	Reverse	Source and destination are reversed
	More	Message sent to more recipients than intended
	Less	Message sent to fewer recipients than intended
Message guard conditions	No/none	The conditions is not evaluated and can have any value (omission)
	Other than	The condition is evaluated true whereas it is false, or vice versa (commission)
	As well as	The condition is well evaluated but other unexpected conditions are true
	Part of	Only a part of conditions is correctly evaluated
Message guard conditions (cont.)	Late	The conditions is evaluated later than required (other dependant conditions have been tested before)
		The conditions is evaluated later than correct synchronisation with environment
Message parameters/ return parameters	No/None	Expected parameters are never set/returned
	More	Parameters values are higher than intended
	Less	Parameter values are lower than intended
	As Well As	Parameters are also transmitted with unexpected ones

	Part of	Only some parameters are transmitted Some parameters are missing
	Other than	Parameter type/number are different from those expected by receiver

Our analysis allows us to derive recommendation how to mitigate the impact of deviations. For instance, it clearly demonstrates that a message omission leads to the system deadlock. Therefore, a timeout mechanism should be implemented to ensure that the goal execution progresses despite possible message omissions.

If an agent sends a confirmation of a task completion then the consequent task might start in an incorrect state. To mitigate this hazard, a coordinator might additionally check to ensure that the required task was indeed completed.

Our analysis of the deviations in the agent behaviour allows us to derive the following recommendations to ensure correctness of agent interactions in the collaborative environments:

- Implement acknowledgement and timeout mechanisms on the communication between the collaborative environment manager and the coalition coordinators during the goal triggering
- Implement acknowledgment, timeout and resend mechanism between the collaborative environment manager and the coalition coordinators for the task completion communication
- Ensure that a reliable level of connectivity is maintained in the collaborative environment to support inter-agent communication.

V. Conclusion and Related Work

In this paper, we have proposed a general model facilitating reasoning about correctness of agent interactions in the collaborative environments. Our analysis is based on formal definition of relations between the goals that collaboration should achieve and states of the agent. A formalization of a goal-oriented development was proposed in [6]. In this paper, the focus was not only on formal representation of relationships between the agents and goals but also on the systematic analysis of deviations.

An approach to integration with other techniques for safety analysis was proposed in [8]. This work is relevant to a high-level analysis of collaboration. An approach to analysis of collaborative behaviour in the context of mode-rich systems was proposed in [9]. The focus of this work was on reasoning about modes of collaborating components.

A formalization of agent collaboration has been performed in [7]. The focus of this work was on tolerating temporal agent failures, while in our work we focused on systematic analysis of deviations in component interactions.

HAZOP analysis has been adapted to analyse human computer-interactions, as well as process deviations. Our use of HAZOP is similar to the former and allows us to reason about interactions of components participating in collaboration.

In this paper, we proposed a systematic approach to analyse agent interactions in collaborative environments. We formally defined relationships between the state of agents and ability of coalition to achieve the required goals. We have demonstrated that the HAZOP method allows us systematically study deviations in the agent interactions and establish a link between errors in interactions and goal achieving.

As a future work, it would be interesting to apply the proposed approach to complex collaborative environment from the Internet of Things domain.

References

[1] DefStan00-58, HAZOP studies on systems containing programmable electronics. Defence Standard, Ministry of Defence, UK, 2007.

[2] IEC61882, Hazard and operability studies (HAZOP studies). Application guide. International Electrotechnical Comission, 2001.

[3] J. Guiochet, D. Martin-Guillerez, and D. Powell, "Experience with Model-Based User-Centered Risk Assessment for Service Robots", HASE 2010: pp. 104-113.

[4] A. van Lamsweerde, "Goal-Oriented Requirements Engineering: A Roundtrip from Research to Practice", Proceedings of RE'04, 12th IEEE Joint International Requirements Engineering Conference, Kyoto, Sept. 2004, pp. 4-8.

[5] OMG-UML2.OMG unified modeling language (UML). Superstructure, v2.1.2, Onject Management Group.

[6] I. Pereverzeva, E. Troubitsyna, and L. Laibinis, "Formal Goal-Oriented Development of Resilient MAS in Event-B", in Proc. of Ada-Europe 2012 --17th International Conference on Reliable Software Technologies. Lecture Notes in Computer Science 7308, pp. 147–161, Springer, June 2012.

[7] L. Laibinis, E. Troubitsyna, A. Iliasov, and A. Romanovsky, "Rigorous Development of Fault-Tolerant Agent Systems", in M. Butler, C. Jones, A. Romanovsky and E. Troubitsyna (Eds.), Rigorous Development of Complex Fault-Tolerant Systems. Lecture Notes in Computer Science, vol. 4157, pp. 241-260, Springer, Berlin, November 2006.

[8] K. Sere and E. Troubitsyna, "Safety Analysis in Formal Specification". In J.M. Wing, J. Woodcock, J. Davies (Eds.) Proc. of FM'99 - Formal Methods: World Congress on Formal Methods in the Development of Computing Systems, Lecture Notes in Computer Science 1709, pp. 1564 – 1583, Springer, France, September 1999.

[9] A. Iliasov, E. Troubitsyna, L. Laibinis, A. Romanovsky, K. Varpaaniemi, D. Ilic et al, "Developing Mode-Rich Satellite Software by Refinement in Event-B", Science of Computer Programming, 78(7), pp. 884-905, 2013.

[10] Internet of Things, [Online]. Available from: www.internet-of-things.eu/ March, 2017.

Influence in AHP–Multiactor Decision Making

Alberto Turón and José María Moreno–Jiménez

Grupo Decisión Multicriterio Zaragoza
Facultad de Economía y Empresa. Universidad de Zaragoza
Zaragoza, Spain
Email: {turon, moreno}@unizar.es

***Abstract*—Collaborative decision making processes exchange information, data and opinions between the actors involved in their resolution. As a result, their preferences are often modified. In order to identify the social leaders (those who influence others), one must analyze the magnitude of the change in each actor's preference structure and its relation to the opinions and preferences expressed by the others. Networks created from the interactions between the actors permit to calculate measures of trust and reputation. In this work, we derive a measure of the influence received by the decision makers, obtained from their confidence in those with whom they interact during a decision making process, carried out by the Analytical Hierarchical Process (AHP) in the framework of e–Cognocracy.**

Keywords–AHP; e-Cognocracy; Trust; Reputation; Influence.

I. Introduction

Decision making in the Knowledge Society is a collaborative task; a correct decision requires individual motivations, but an effective decision also requires the acquisition of information from external sources to assess the outcomes of the decision made. In a decision making process, several actors or agents intervene, exchanging opinions and data, and providing arguments through debates.

These actors have channels through which to exchange this information, constituting a network in which this exchange often coexists with another series of actions or experiences shared by the same decision makers, belonging to areas beyond the decision in question. The set of actions that the actors carry out in the network, together with the information that some actors obtain from others, generate trust in one another. In turn, actors earn a reputation, which can make them influential. In order to understand the nature of the decision making processes, it is important to identify the social leaders -the persons whose opinions influence the preferences of others, and to obtain a measure of how they influence the other actors' preferences.

This paper details the way to obtain the network of influence of the actors involved in group decision and, from them, determine their influence, in the framework of a decision making process that uses the Analytic Hierarchy Process (AHP) under the paradigm of e-Cognocracy.

The rest of this paper is organized as follows. Section II introduces the concepts of reputation and influence, the methodology on which the calculation of influence, known as e-Cognocracy, is based, and the multicriteria approach used, AHP. Section III shows the proposed procedure for determining the influence of decision makers and their relationship with reputation. Section IV shows the results obtained in a real experience that was carried out following this methodology. Finally, Section V contains the most outstanding conclusions of this work, as well as possible extensions of the same and future lines of work.

II. Background

The determination of influence requires the calculation of trust between actors and the reputation of each of them. On the other hand, the present study has been carried out using the AHP methodology for decision making, within the e-Cognocracy framework.

A. Trust, reputation and influence

Trust and reputation are studied in many different disciplines [1] as key factors to explain the behavior of people integrated into social networks.

We can consider that, given a set of actors $D = \{D_1, \ldots, D_N\}$, the trust τ_{ij} of the actor D_i in the actor D_j is the expectation that D_i puts in that D_j adopts a certain behavior at a given moment (see, for example, [2]). While the reputation r_i of the actor D_i is a measure of the prestige that D_i has among the other actors, understood as the perception that the agent creates past actions about its intentions and norms [1]. Trust is a subjective indicator, which is usually built on the basis of the personal impressions that an actor derives from another, through the observation of the interactions between them; the reputation of an actor is a single value obtained from observations carried out in the social network to which the actor belongs [3].

Finally, reputation of an actor can influence the preferences of other actors.

B. E–Cognocracy

The e-Cognocracy is a new model of democracy that emerged in 2003 as a system to integrate immigration into the Knowledge Society [4]. Since then, the Multicriteria Decision Making Group (GDMZ), a research group from the University of Zaragoza, has been developing new philosophical arguments to support its evolution and numerous technological and methodological tools for its implementation.

E-Cognocracy combines the two most widespread models of democracy at the beginning of the twenty-first century [5]: representative or liberal democracy and participatory or direct democracy. In this way, some of the limitations of representative democracies (lack of transparency and accountability of representatives, and lack of participation and control of citizens) and direct democracies (populism, overvaluation of

 ISBN: 978-1-61208-575-3

individual interests, lack of a long-term vision of the system, etc.) are resolved.

In terms of its methodology, e-Cognocracy consists of seven basic stages: (i) problem formulation; (ii) first voting round; (iii) discussion; (iv) second voting round; (v) knowledge extraction, (vi) evaluation; (vii) documentation.

C. Analytic Hierarchy Process (AHP)

The AHP [6],[7] is a technique that allows the resolution of multicriteria, multienvironment and multiactor problems, incorporating into the model the subjective aspects and the inherent uncertainty in the decision making of real systems. This multicriteria technique combines the objective associated to traditional science with the subjective associated to human being. It also presents a well behavior in multiactor decision making. Some main features of this method are: the modeling of the problem through the construction of a hierarchy in which the relevant aspects of the problem (criteria, alternatives, etc.) are collected; the incorporation of preferences through pairwise comparisons; and the deduction of a ratio scale derived from relative preferences (judgements) measured on an absolute scale.

Another of the most outstanding features of this multicriterion methodology is the possibility of evaluating the decision maker's consistency in the issuance of judgments, not being necessary that such judgments be perfectly consistent or cardinal transitive.

Basically, the original AHP method consists of four stages: (1) construction of a model, in this case a hierarchy, that represents the decision problem; (2) incorporation of the decision maker's judgments; this is made by making paired comparisons between the elements of the same level of the hierarchy with respect to the common node of the next higher level; in this way, each judgment focuses on the comparison of two elements with respect to a single characteristic; (3) calculation, from the pairwise comparison matrices issued by the decision maker in the previous stage, of the values that determine the relative importance of the elements of a level with respect to a node of the higher level (local priorities) and then the global priorities of all the elements of the hierarchy are obtained; and (4) synthesis of the global priorities of the alternatives to obtain their total or final priorities.

III. Determination of the influences

In a discrete multicriteria multiactor decision problem following the methodology of e-Cognocracy, the preference structure of each decision maker can be modified from the first round to the second. This modification may be due to the influence received during the discussion stage, after analyzing the contribution of the other actors. The result of all the interactions that take place during the debate process is a matrix of trusts $\mathcal{T} = (\tau_{ij})_{N\times N}$ (some may be empty, if there is no interaction between two actors), and a vector of reputations $R = (r_1, \ldots, r_N)^T$. The interactions between the decision makers (corresponding to the non-null elements of $\mathcal{T}$) define a network of trusts, that is, a directed acyclic graph $G(D, E)$ in which the vertices are the actors and $E = (e_{ij})$ is the matrix of adjacencies of the graph G:

$$e_{ij} = \begin{cases} 1 & \text{if } D_i \,\Re\, D_j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where $\Re$ is the relationship $D_i \Re D_j \Leftrightarrow D_j$ has generated trust in D_i.

If $A = \{A_1, \ldots, A_M\}$ are the alternatives and $w^k = (\omega_1^k, \ldots, \omega_M^k)$ the preference structure of the decision maker D_k, then $w^k \in \mathcal{S}^M$ for $k = 1, \ldots, N$, being

$$\mathcal{S}^M = \{(w_1, \ldots, w_M) \mid w_i \geq 0 \text{ and } \sum_{i=1}^{M} w_i = 1\} \quad (2)$$

the compositional space or *simplex* M-dimensional.

In order to determine the influence that each actor has received from those with whom it has interacted, the *center of influence* of each actor D_i is calculated, that is, a representative position of all the actors that have exerted their influence on him. This position corresponds to the arithmetic mean of the preference structures of the decision makers D_j belonging to his/her network of influences, weighted by the trust τ_{ij}:

$$\Pi_i = \left(\frac{\sum_{j=1}^{M} \tau_{ij} x_1^j e_{ij}}{\sum_{j=1}^{M} \tau_{ij} e_{ij}}, \ldots, \frac{\sum_{j=1}^{M} \tau_{ij} x_{M-1}^j e_{ij}}{\sum_{j=1}^{M} \tau_{ij} e_{ij}} \right) \quad (3)$$

and $x^j = (x_1^j, \ldots, x_{M-1}^j)$ is the projection of the preference structure w^j of actor D_j in the last round (final decision) on the Cartesian space $\mathbb{R}^{M-1}$, using the centered log-ratio transform

$$x_i^j = log \left(\frac{\omega_i^j}{\left(\prod_{k=1}^{M} \omega_k^j \right)^{1/M}} \right), i = 1, \ldots, M-1 \quad (4)$$

The purpose of this transformation is to convert a decision maker's preference structure into values for which it makes sense to calculate Cartesian distances. The extent to which the distance between the position of the decision maker D_i and his/her center of influence has changed between rounds is a measure of the influence received.

IV. Application to a real experience

In April 2015 an experiment was carried out on the selection of the best mobility strategy in the city of Zaragoza, taking as a starting point the tram line existing at that time. The problem consisted of four alternatives, proposed by four political parties, and was carried out in two voting rounds with an intermediate debate, in which the students of the subject *Electronic Government and Public Decisions* intervened, and to which were also invited the representatives of the political parties that presented candidacy to the Council of Zaragoza for the impending municipal elections [8]. In total, 27 people participated in the discussion, although only 16 of them participated in the two rounds of voting, and therefore they were the only ones with whom this study could be carried out. The discussion took place on the Social Cognocracy Network (SCN) [9], a social network designed by the GDMZ based on the e-Cognocracy. Through this social network, the discussion stage provides measures of the actors' trust and reputation [10].

After the first voting round, a discussion was developed in the forum, with the participation of the students and the political representatives. In the forum, each actor D_j could valuate the reputation of the others, as well as the importance of the topics and the comments to the topics that were posted, by giving values from 0 to 10 to three quantitative indices:

Index	**Rates**
Trust τ_{ij}	The author D_i of a comment
T–importance I_{ij}^T	A topic T_i
C–importance I_{ij}^C	A comment C_i

Actors were also able to assess the importance of their own topics and comments, and even to rate themselves *(self-trust)*.

From these indices, the reputation r_i of each actor and the relevance of topics (R_i^T) and comments (R_i^C) were obtained, using the expressions:

$$r_i = \frac{\sum_{j=1}^{n} r_j \tau_{ij}}{\sum_{j=1}^{n} r_j}, R_i^T = \frac{\sum_{j=1}^{n} r_j I_{ij}^T}{\sum_{j=1}^{n} r_j}, \quad R_i^C = \left(1 + \frac{n_c}{N}\right) \frac{\sum_{j=1}^{n} r_j I_{ij}^C}{\sum_{j=1}^{n} r_j} \tag{5}$$

being N the total number of comments posted to a topic and n_c the number of answers to a specific comment in that topic. This process is recursive, so that a valuation emitted at an instant modifies the previous values, that are recalculated.

Then, a second voting round was performed, and the voters' preference structures were obtained.

Figure 1 shows the influence network obtained after the discussion stage, as well as the reputation and the preferred alternative of the actors who participated in the three stages. Table I shows the values obtained for the influence index after the two voting rounds and the discussion.

Analyzing the reputation and the influence indices, several well differentiated profiles are found:

1) Users with a high influence index and a low reputation, whose network of influence is formed by high reputation users: U00041G, U00057H.
2) Users with a low influence index and a high reputation, whose network of influence is formed by users of high reputation: U00002C, U00018D, L19, Omael for President, U00042C.
3) Users with a low influence index and a low reputation, whose network of influence is formed by high reputation users: U00003I, Johnny Snow, U00031B.
4) Other users: Humano anonimo, Paul Gascoigne, U00027C, U00034J, U00039J, U00047C.

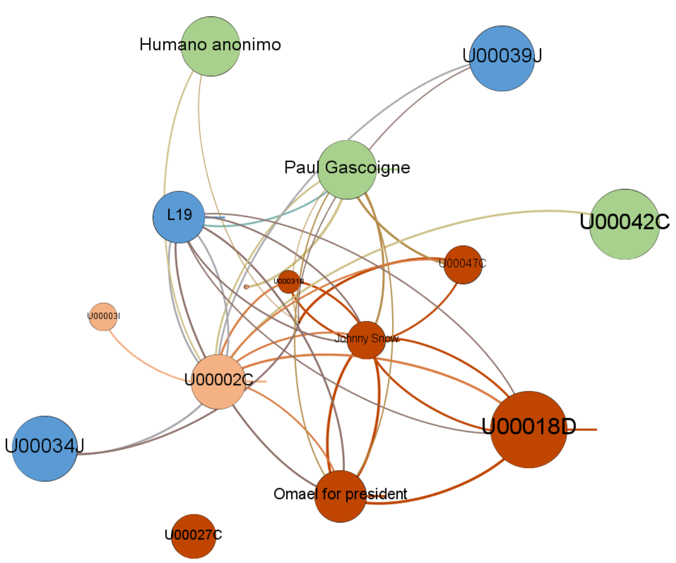


Figure 1. Network of influence created during the discussion in the forum. The colors represent the preferred alternative after the second voting round, and the size of each node is proportional to the reputation of the decision maker it represents.

Users with profile 4 correspond to cases in which no clear pattern can be identified, either because the number of influencers is scarce or because their network of influence is composed of people of very different reputations. The three other profiles are perfectly characterized, observing how all the decision makers with high influence index (first profile) have modified their main decision between one round and another, behavior that is not observed in the decision makers with low influence rates.

V. Conclusions and Future Work

Based on the reputations of the decision makers obtained in a multiactor decision making process, we construct an indicator of the influence that a decision maker receives from the actors with whom he interacts. This indicator makes it possible to identify the most influential actors and, consequently, those who have received a greater influence from others. These others can be identified through his/her network of influence.

Our future work will focus on the analysis of the content of the messages using text mining techniques, which will allow for the combination of the quantitative analysis with a qualitative analysis that accurately identifies the arguments presented during the debate.

Acknowledgment

This research was funded by the Spanish Ministry of Economy and Competitiveness along with FEDER funding (Project ECO2015-66673-R).

References

[1] L. Mui, M. Mohtashemi, and A. Halberstadt, "A computational model of trust and reputation", The 35th Hawaii International Conference on System Sciences (HICSS 35'02) IEEE, 2002, pp. 2431–2439.

[2] A. Jøsang, "Trust and reputation systems", Foundations of Security Analysis and Design IV. Lecture Notes in Computer Science, vol 4677, A. Aldini and R. Gorrieri, Eds. Springer, Berlin, Heidelberg, 2007, pp. 209–245.

[3] M. Granovetter, "Economic action and social structure: the problem of embeddedness", American Journal of Sociology, 91, 1985, pp. 481–510.

[4] J. M. Moreno-Jiménez, "The new technologies and the democratic representation of the immigrant", IV Jornadas Jurídicas de Albarracín. Consejo General del Poder Judicial. TSJA, Memoria Judicial Anual de Aragón, J. Arenere, Ed, 2003, p. 66.

[5] J. M. Moreno-Jiménez, "E–cognocracy: new society, new democracy", Estudios de Economía Aplicada vol. 24(1-2), 2006, pp. 559–581.

[6] T. L. Saaty, "A scaling method for priorities in hierarchical structures," Journal of Mathematical Psychology, vol. 15 (3), 1977, pp. 234–281.

[7] T. L. Saaty, "The Analytic Hierarchy Process," McGraw-Hill, 1980.

[8] M. T. Escobar, J. Aguarón, and J. M. Moreno-Jiménez, "Multicriteria selection of a mobility strategy in the city of Zaragoza", Actas del XXX Congreso Internacional de Economía Aplicada Asepelt 2016, Valencia, 2016, pp. 898–910.

[9] A. Turón, J. Aguarón, J. M. Moreno-Jiménez, and M. T. Escobar, ”Notes on leadership identification in Social Cognocracy Network”, Proceedings of the Joint International Conference of the INFORMS GDN Section and the EURO Working Group on DSS GDN 2014, Toulouse, 2014, p. 338.

[10] A. Turón, J. Aguarón, J. M. Moreno-Jiménez, and M. T. Escobar, ”An experience on leadership Identification in Social Cognocracy Network”, Proceedings of the Fifth International Conference on Advanced Collaborative Networks, Systems and Applications COLLA 2015, St. Julians (Malta), 2015, pp. 57–58.

TABLE I. INFLUENCE INDICES.

Decision maker	*Reputation*	*Distance round 1*	*Distance round 2*	*Influence*	*Decision round 1*	*Decision round 2*
U00002C	6.19	0.66551	0.63466	-0.03085	A3	A2
U00003I	3.08	0.81759	1.13344	+0.31584	A2	A2
Johnny Snow	4.24	0.21064	0.16989	-0.04075	A4	A4
Humano anonimo	6.70	0.99191	0.89467	-0.09723	A3	A3
U00018D	8.75	0.41301	0.41553	+0.00253	A1	A4
L19	5.82	0.44337	0.68249	+0.23912	A1	A1
Paul Gascoigne	6.67	0.53453	0.00000	-0.53453	A3	A3
Omael for president	5.84	0.73748	0.67757	-0.05991	A3	A4
U00027C	5.00	1.26954	1.29257	+0.02303	A4	A4
U00031B	2.45	0.21124	0.06888	-0.14236	A4	A4
U00034J	7.38	1.54429	1.53257	-0.01172	A1	A1
U00039J	7.38	0.42917	0.76707	+0.33790	A4	A1
U00041G	0.31	0.40665	0.00000	-0.40665	A1	A2
U00042C	8.00	1.00044	0.71582	-0.28463	A2	A3
U00047C	4.23	0.49455	0.47847	-0.01608	A4	A4
U00057H	0.00	0.75448	1.54259	+0.78811	A3	A4