SUPPORTING ANNOTATION-BASED ARGUMENTATION LINKING DISCURSIVE AND GRAPHICAL ASPECTS OF DESIGN FOR ASYNCHRONOUS COMMUNICATION

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ABSTRACT.
In this paper we will focus on distant collaborative design activities. Graphic representations have always played an important role in design. If one look back in the history of engineering, graphic representations has always been strongly present. Drawings, sketches, mock-ups, and more recently digital representations (CAD, virtual reality, etc.) are commonly shared in design teams. For many years researchers have been studying the role of mediating objects in design teams, facilitating common understanding and knowledge elicitation and sharing. More recently some works have focused on the argumentative side of design. Indeed, the discursive aspect of design is almost as important as the graphic one. In relation to these observations we discuss the concept of intermediary object, boundary object and transactive memory as a good theoretical framework. Today new technologies enable to rethink the mediating structures in distant collaborative work. Particularly we have studied the role of annotations for linking discursive and graphical aspects of design. This led us to develop an annotation plate-form we will present and propose to the discussion.

Keywords: Design communication, shared understanding, shared representation, intermediary object, argumentation, asynchronous communication.

1 INTRODUCTION

Design as an art, as an activity or as a science has been studied for a long time. This is a fascinating human activity that is at the origin of most of our material welfare, allowing the creation of a huge variety of artifacts that assist the human beings in their everyday life. In the late 60's Herbert Simon suggested that design could be considered as a science [1]: Design is a science of the artificial, therefore allowing the study of a great number of human activities under this new paradigm. Because the act of designing is everywhere in our life it is certainly not limited to the design offices or the architects' studios.

After these works we know that we cannot think design into the finite and closed world of an existing reality. Which means that studying design requires to adopt a constructivist point of view on the observed phenomenon. From a philosophical point of view, design is a teleology where designers invent new artifacts in relation to an end and a given purpose. But designers must shape a future object on the basis of an unknown future, this future being influenced by the object that is being designed. This is a recursive process requiring the co-definition of the object and the environment (industrial, social, etc.). Creativity and design are consubstantial.

But design is also a social process [2] and therefore considering design as only being a cognitive and personal activity appears to be too limited, especially regarding what is happening in the companies today. A wide variety of experts must cooperate in order to deal with the growing complexity of the designed artifacts. Being they called designers, experts, participants, stakeholders, etc., these people are involved in the collective effort towards producing a new artifact. Therefore the collaborative dimension of design cannot be avoided as well.

In companies the design work is mostly organized around multidisciplinary teams that are partially co-located. Most of the time some developments are realized by distant sub-teams belonging to sub-contractors or partners. The paper deals with problems encountered by these teams in their everyday and mostly informal communication. This communication is of course widely mediated through

various computer and digital representations. In the following we will investigate the role of these representations and their status in the collaborative process.

2 DESIGN COMMUNICATION

On the one hand, a design representation should be unambiguous and precise in order to support design reasoning and evaluation, while on the other hand, communication requires redundancy, overlapping, meaning negotiation, etc. These two aspects are clearly conflicting [3]. Besides, ambiguity is often raised as an important factor that fosters creativity. So the communication needs will be different if we consider creative fuzzy front end phases or if we consider down stream development phases. The level of definition of the product is supposed to increase as well as the ambiguity is supposed to reduce as the design process goes on.

Communication is a relational process that encompasses at least two partners that are involved in this process. We will adopt here a constructivist point of view on communication in design considering that communication is a process of creating a shared understanding between the partners and is the consequence of complex interrelation between the subjects and the world. Communication requires shared rules, language, and a goal. Design experts are very aware of the importance of the traces and the content of the messages they share. This is why an approach purely concentrated on the information flow is not relevant for us. We argue that the context and the form of the media play a fundamental role in design communication. Therefore we concentrate also on the vehicle of the information, especially because in the digital era most of our interactions are mediated by digital artifacts. Because most of the industrial efforts concentrate on information flow structuring, there is a clear need of proper digital supports for mediating design communication and particularly its discursive dimension.

2.1 The effect of distance on design communication

Distance clearly affects design communication and distributed design is a growing field of interest. However most of the efforts concentrate on the physical distance between designers. We propose to distinguish between three kinds of distances that affect design communication:

- The physical distance, that refers to the places where the designers sit. They can be spread around the world, in different companies or in different departments of the same company, etc. This physical distance materially affects the communication by reducing the channels of communication (i.e. verbal, visual, tactile, etc.)
- The cognitive distance is an important issue as it may affect also co-located partners. This cognitive distance is related to the fact that the specialists have different references, objectives, values, etc. depending on their domain. For example a design expert may have a different educational background than a marketing expert and therefore they may attach different values to the same thing. We commonly say that they have a different point of view on the same object.
- The cultural distance currently appears when the participants do not belong to the same country (this is the most obvious case, but not the only one). This is obvious when Western companies work with Asia for example, but it is also true between Western countries. Even if the participants speak the same language (e.g. English), the underlying traditions may affect the understanding of the participants to a meeting and all the cultural implicit may become a barrier to a good communication.

These three dimensions must be addressed for achieving a good communication. In this paper we will more particularly concentrate on the cognitive aspects and the good vehicles (mediating artifacts) for the creation of a shared understanding in design teams.

2.2 Artifacts and intermediary objects in the process of creating a shared understanding

In this section we will discuss the cognitive dimension of the artifacts involved in design. We call them design artifacts as these artifacts are part of the product during the course of design. They are the intermediate states of a product that still does not exist. But their materiality (including digital objects) allows them to evolve in the external world and to be grasped by various stakeholders. By cognitive dimension, we mean that design artifacts provide a support to the memory of the participants just as a part of the group's transactive memory [4]. And as the artifacts are shared among the group, this memory allows group members to quickly identify knowledge sources, expertise and abilities of the

others in order to improve the efficiency of the communication between the members. This cognitive dimension allows the participants to create shared understanding and make decisions. For us the artifact is tightly related to the subject that created it and to the group that will use it. A mock-up or bits of product has no sense out of the context of its creation or its usage.

Studying experts' work Bucciarelli defined the concept of object world [5] as a set of references and knowledge that every expert has embodied during his past experiences and that gives him a unique and particular nature. Going further on [6] described object world languages attached to individuals as a source of many misunderstandings even if, externally, everybody is apparently speaking the same common language (e.g. English).

An object world is a world of a variety of things particular and specialized modes of representation. Object worlds have their own unique instruments, reference texts, prototypical bits of hardware, tools, suppliers' catalogues, codes and unwritten rules… Each object world language of an engineer is rooted in a particular scientific paradigm which serves as a basis for conjecture, analysis, testing – and designing – within that world.Given that for granted, how can we speak of shared representation if any individual has a specific language? How can cooperation be possible then?

If we consider individuals as isolated islands, therefore any communication must cross the boundaries of these islands. In the external world the obvious things that are shared across these islands are the design artifacts. Some of these artifacts remain inside the island (drafts, specific models of simulation, etc.) but others cross the boundaries and are shared during design meetings for example. The concept of boundary object gave a framework for classifying and identifying these artifacts [7]. This proved to be very helpful for design research. But analyzing more deeply the nature of these shared objects we found that they were related to the individuals object worlds and also part of this transactive memory, the material side then allowing the others to grasp the object and create or activate knowledge out of the analysis.

The shared objects clearly have two sides: a material side and a cognitive side, which led to coin the concept of Design Intermediary Object [8]:

- An intermediary object is a representation and therefore the sense of this representation is attached to the context and to the individual that interprets this representation.
- An intermediary object facilitates the co-operation within the group: it has a mediation role and its form influences the performance of the communication.
- An intermediary object is involved in a translation process and may act as a spokes-person [9], for example if a given actor is not present during the meeting.

Design intermediary objects can also be analysed within the framework of many other approaches. We have successfully linked DIO and the situated FBS [10] and show how these intermediary objects can be the vehicles of the shared understanding between internal worlds and the external world as defined by Gero et al. [11]. DIO are a part of the shared understanding if we consider that shared understanding is a process. Kliensmann and Valkenburg [12] defined the concept of shared understanding as:

"a similarity in the individual perceptions of actors about either how the design content is conceptualized (content) or how the transactive memory system works (process)"

As design constantly evolves, the context of the design also evolves. Therefore the similarities in the perceptions also are subject to evolution. This is why we consider that, in the same way some consider the "process of knowing" we consider that shared understanding is a process, and in a way DIO can be seen as the external vehicle of this process, the material side of a cognitive process.

3 ANNOTATIONS AS A MEANS TO SUPPORT ARGUMENTATION AND COLLABORATIVE DESIGN DEBATE

As an illustration of the process of creating shared understanding, we observed, as many other authors that during design meetings, the argumentation developed by the stakeholders were the source of many rich improvements in the understanding of the designers and also a keystone of the decision making process. Then how can design intermediary object be more open to explicitly support the argumentative side of design?

We propose therefore to focus on the argumentative process and analyze its role in design debates. We also propose to analyze annotations as good candidates for the creation of specific objects for supporting argumentation during design debates.

3.1 Qualifying argumentation and design debate

Argumentation is a key element of any logical discourse that aims at demonstrating or convincing someone else. Argumentation includes debate and negotiation which are concerned with reaching mutually acceptable conclusions. In Logic an argument is a set of one or more meaningful declarative sentences called “propositions” that can take the value “true” or “false” or even “unknown”. However, the study of human discourse cannot be limited to pure logical status when we consider the discursive aspect of argumentation. In a discourse an argument can be used for various purposes (i.e. statement, proposition, indication, etc.), and the question of the truthfulness of the argument is seldom considered. Mostly argumentation is used for convincing someone, presenting or defending a position, explaining or justifying a decision. This is also true in the particular case of design.

Argumentation in design has not been studied very much despite it plays an important role in decision making. In design reviews, designers and other stockholders present and discuss the proposed solutions. Design review meetings are privileged place where design debates occur, but it should be an error to strictly limit design debates to design meetings, as informal debates also occur all the time. The debates rely on the expertise of the participants and on the analysis performed before the design meetings and allow the participants to express their point of view. This point of view is therefore defended by various assertion or statements we call arguments. Previous works have proposed some interesting classifications of these arguments. For example Detienne and al. [13] proposed a classification based on 8 categories among which 5 are dedicated to the argumentation, proposition, and clarification of the design. While Lund and al. [14] propose an approach for studying computer-mediated debates with 7 categories among which 3 are dedicated to the object of the debate (opinion, argumentation, deepen), in our case: the solution to be evaluated.

3.2 Annotations that support the discussions during design meetings

Lang et al. [15] made an interesting summary of the requirements for an environment that supports collaborative design. Among the main factors that influence collaborative design the authors identified cognitive factors such as cognitive synchronisation and highlight negotiation as an important factor for achieving good collaboration. Among all the tools referenced in this study, the authors surprisingly never mentioned annotation tools as good candidates for supporting collaboration. This is a good illustration of the gap between engineering tools (CAD, CAE, etc.) and collaborative tools or groupware. Our aim is to integrate into design oriented platforms some groupware functionalities such as annotation functionalities.

Annotation has been recognized as an important activity primarily in text elaboration. From the ancient religious text comments to the modern digital text collaborative editing, annotation has been the main way people used for expressing themselves about a given text and attached to it. More recently annotation has been recognized as an important way for supporting argumentative episodes in design meetings. In that case, annotations are mainly graphical or mixed textual and graphical and serve as a support for expressing an idea, supporting an argument, highlighting a specific point. These annotations loose there meaning out of the context of their creation. There is no persistence of the interpretability, even for specialists. These annotations may keep some sense if they are integrated in an environment that records the meeting itself and stores the video and audio transcript of the meetings [16].

Guibert et al. [17] have exposed the main characteristics of the annotations in the case of engineering design. For these authors an annotation always refers to a target document that may have various forms. The content refers to the information that aims to be transmitted. The anchor of the annotation corresponds to the geometric point designating the zone the annotation refers to. An annotation may be private or public. The life span of an annotation may vary but remains linked to the lifespan of the document. The author of the annotation may or may not be the author of the document.

It is interesting to notice the clear distinction made by the authors between the document and the annotation that refers to the document. This distinction is not so clear when confronted to actual practices and the analysis of sketches created during design meetings (fig. 1).

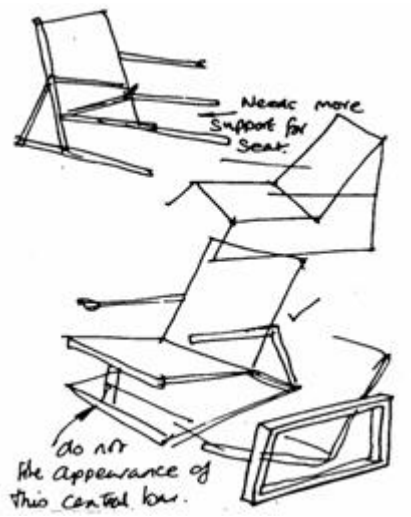

Figure 1: It is difficult to distinguish annotation from the document reference of this annotated sketch.

In that case annotations are good media for discussion and synchronous debate, but rater poor media for memory and information transmission for future reuse.

3.3 Annotations that support asynchronous exchanges

In engineering design most of the representations that transit among the designers are CAD models and these CAD models are mostly using dedicated formats. The full CAD models are very heavy and not easily shared outside the sphere of the design experts. Ding and Mc Mahon [18] propose to introduce the concept of lightweight representation, which is a simplified digital representation independent from any commercial software, therefore easily shared transferred and interpreted by external web based software for example. This approach is providing a good way for introducing multi-layer markups within a lightweight geometric representation. These markups are used for triggering other calculation in an automatic way providing automatic information computation for the experts. Figure 2 shows the result of an FEM calculation related to a markup previously positioned on the lightweight shared model. Unfortunately this work remains limited to the markup technology and does not extend towards the cognitive dimension of the annotation.

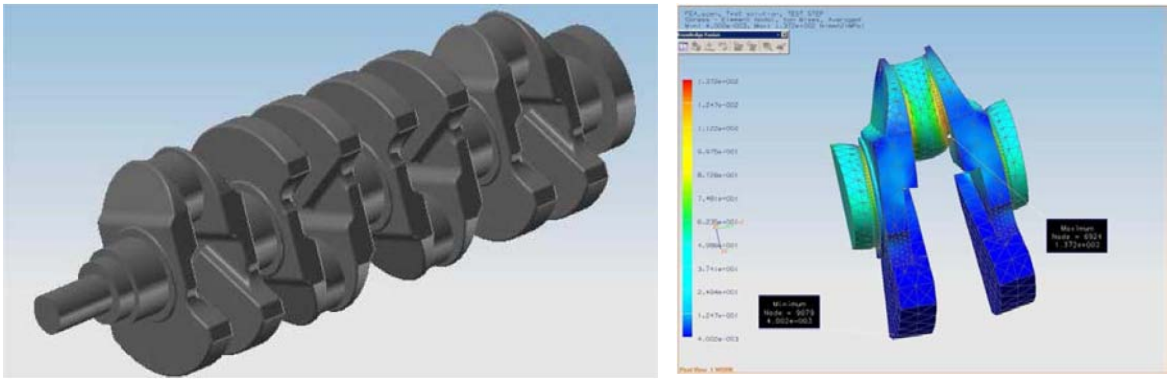

Figure 2: FEA linked to a lightweight representation from [18]

Another interesting work concerning annotations linked to CAD environment proposes to integrate semantic metadata in a simple knowledge model describing the main terminology of the domain. This facilitates the creation of the annotation and simplifies the exploitation of the annotated documents (fig. 3).

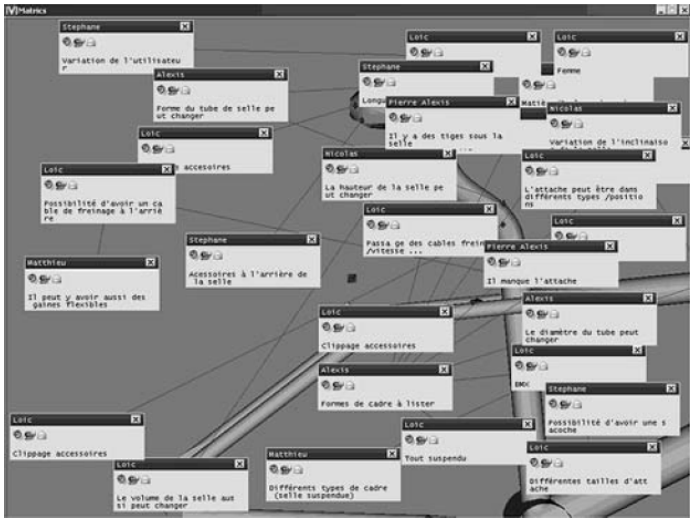

Figure 3: a great number of annotations require appropriate search and sort tools [22]

These work show a brief state of the art of some interesting attempts to introduce some richer semantic into digital design environments. They provide a good help for project memories and storing of some design rational elements. These attempts however neglect the discursive aspect of design being it synchronous or asynchronous. We will see now a work that aims at integrating discursive and design rational element into lightweight 3D platforms.

4 ANNOTATION BASED SHARED REPRESENTATIONS FOR SUPPORTING ASYNCHRONOUS COMMUNICATION

This section presents a collaborative plate-form that has been designed for enhancing asynchronous communication in design teams. We will briefly present the concepts of the tool and discus them with regard to the concepts exposed before.

Most of the annotation tools developed in the field of engineering design assist asynchronous communication. This is the case of the two examples presented in the previous section. The literature often distinguishes between asynchronous and synchronous work and proposes to deal with either one or the other. If we adopt communication point of view on design this distinction becomes a barrier as professional communication in design occur in both situations. Particularly in distributed teams where people may even work on very different time zones. During our fieldwork we have observed a recursive sequence in the teams' design work. This loop involves synchronous and asynchronous work (fig. 4) and a wide variety of shared objects.

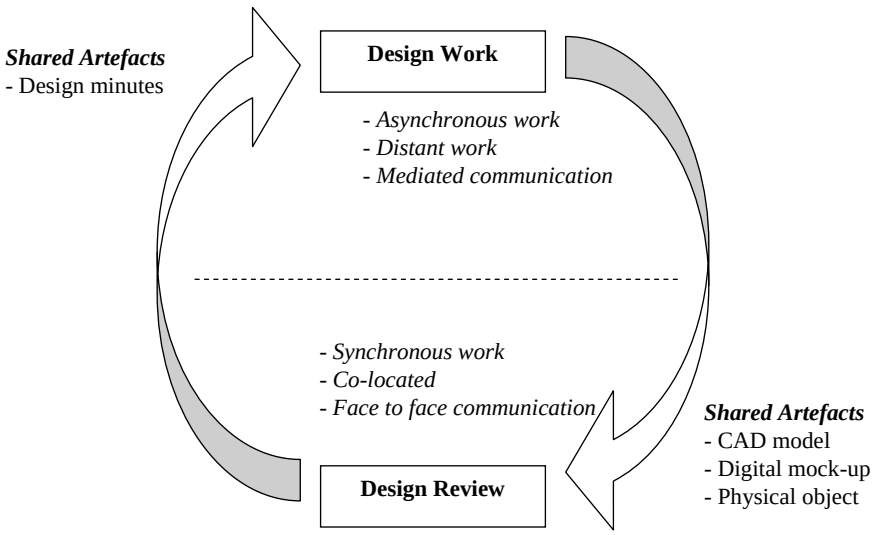

Figure 4: mediated communication in design: a basic pattern

The design reviews (or design meetings) are the most classical cases where a communication approach is important but what we noticed during this study is the deep interrelation between the two phases and the need for smooth information and communication flows. What forms of design intermediary objects are relevant for supporting the design teams across all the process and to allow a communication continuum between synchronous and asynchronous phases?
The aim of the system is to bridge the gap between design work and design review by providing a plate-form for sharing information and initiating a debate in asynchronous mode while providing a synthesis that can be used during design meeting.

4.1 THE SEMANTIC ANNOTATION MODEL

Our model is based on semantic annotation principles considering the annotation as an additional set of information (see section 2.2) that carries a certain meaning and with a certain purpose in a given context. We have been deeply influenced by the speech act theory [19], [20] and is consistent with our approach of design communication exposed before. Speech act theory indicates three dimensions of a given message: the locutory, illocutory and perlocutory dimensions. We concentrate here on the locutory and illocutory dimensions and consider that the structure of our application should support these two dimensions. Indeed most of the approaches only concentrate on the locutory dimension forgetting that the illocutory side which is the case of almost all the PDM systems today. This may lead to misunderstandings for the obvious reason that a simple utterance like: “this is green”, may have a very different purpose depending on the context: it can be either a clarification or an evaluation for example.

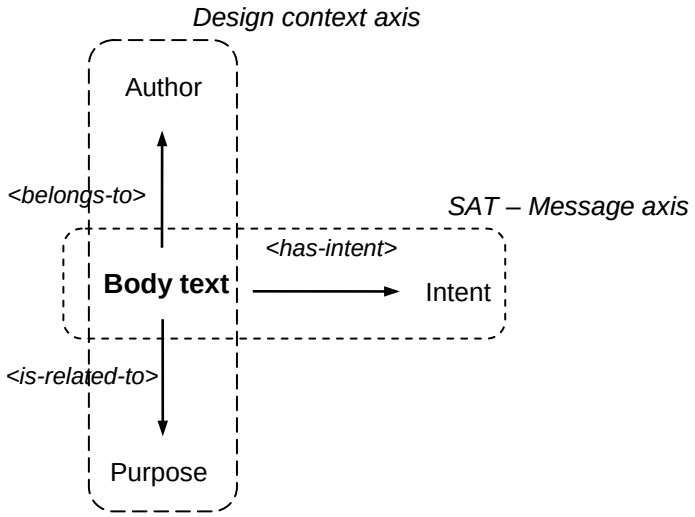

Figure 5: The Annot’action’s annotation model

Our model includes two axes (fig. 5): a message axis and a context axis. One design context axis dedicated to indicate some element of context (e.g. the author and the object), the second axis reflect the SAT concepts storing the intent behind the annotation (the intent). For example, the designer (author) may say “this pipe is too long” referring to the solution (purpose) and intending to evaluate (intent).

The annotation is then defined as:
Annotation = {body text, author, purpose, intent}

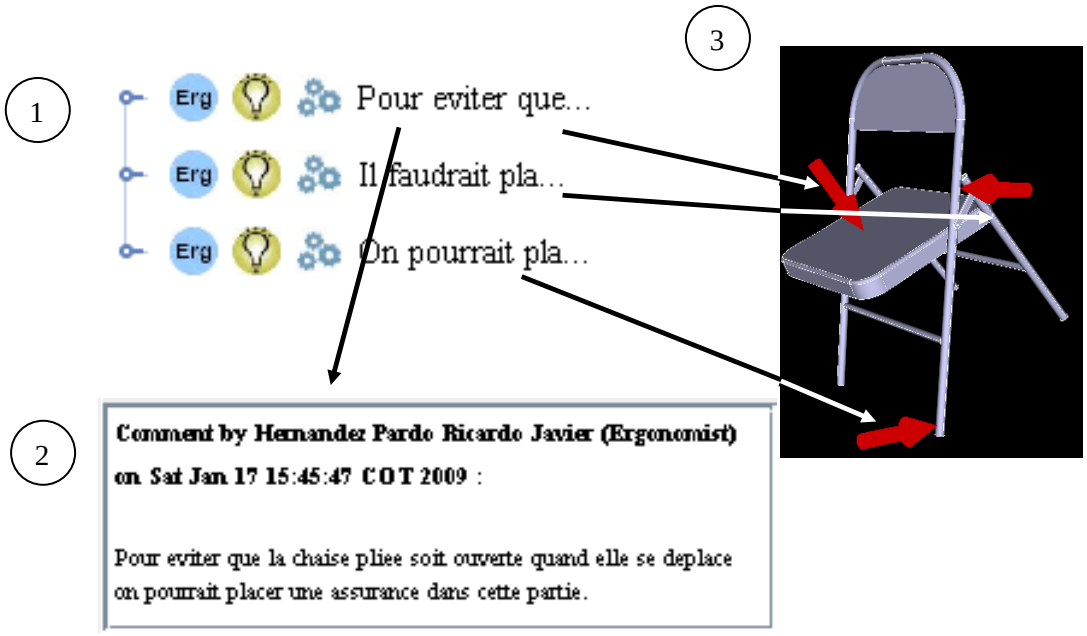

Figure 6: Three levels of representations

On figure 6 we find an illustration of the annotation model. On the top left (1) we have a synthetic view of the context of the annotation with 3 symbols. The first one indicates the author, the second one the intent and the third one the purpose of the annotation, all this representing the illocutory dimension of the message. On the bottom (2) we have the utterance itself, the text of the annotation and on the right (3) we find the graphic representation with the geometric pointer referring to the impacted zone. An annotation is associated with one pointer and can be composed of as many as sub layers as necessary. All this depends on the discussions engaged between the participants.

5 DISCUSSION

Figure 7 shows a short discussion between two participants. The ergonomist ask for an additional feature for the product in order to improve the security. The ergonomist adds some clarification to the proposal and the designer answers with a technical solution proposal. Later, this point has been discussed during the design meeting on the basis of this exchange and a decision has been made. Through this short excerpt we see how two points of view have been expressed and related to the same subject. This example tends to show that through a basic and relatively simple message system, the stakeholders could more easily elicit their points and discuss during the design meeting. The system acted as a kind of memory helper by recalling the points to be discussed, and particularly the arguments that have been raised by the participants.

Through the discussion thread we have a trace of the preliminary exchanges and the participants can come back later to the point and expand their arguments during face to face meetings. These observations tend to support the idea that the participants developed a transactive memory as they shared some argumentations which progressively allowed some cross learning on each others' capacities, expert knowledge, etc. and that on the basis of a real exchange and not on the basis of a reputation.

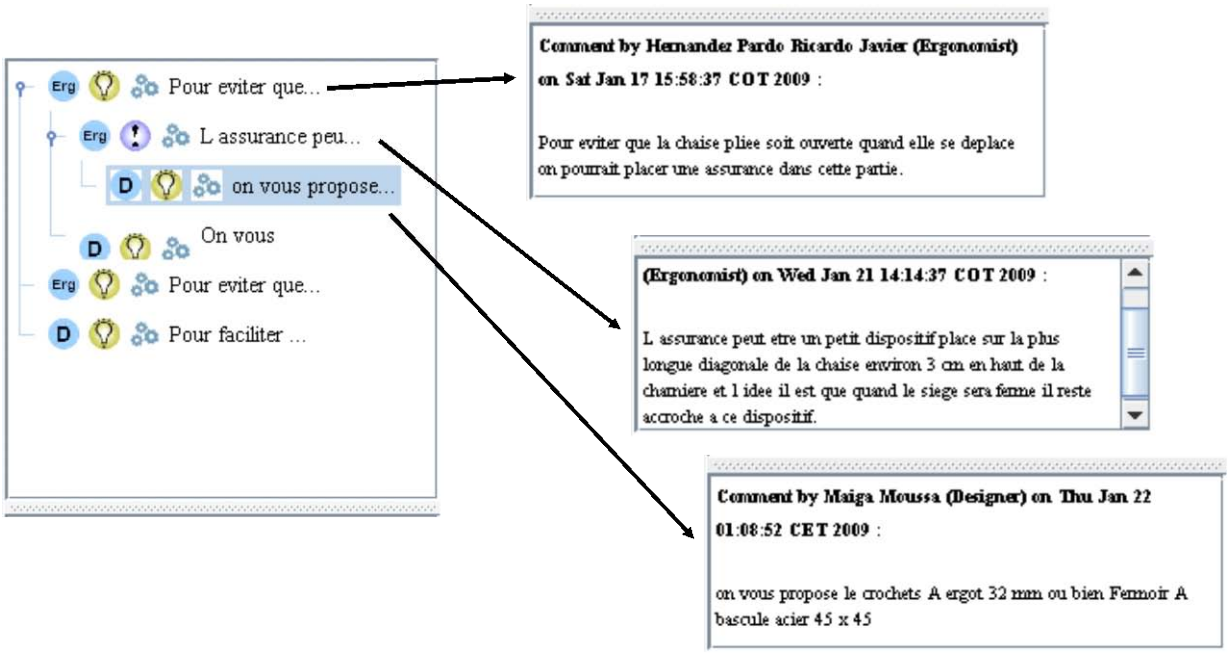

Figure 7: Example of an argumentation thread

In this paper we have developed the thesis that design communication can be assisted and eventually improved by supporting argumentative exchanges among design teams. Most of the design software neglects this dimension of collaboration and the discursive dimension is seldom considered as a relevant aspect for developing design software. The support to communication is then achieved by providing software features that allow the creation of proper shared representations that link graphic (3D in our case) and discursive dimensions. As Schön [21] stated, design is a conversation with the design situation, involving all sorts of media, and essentially graphic representations. Therefore we need to provide graphic representations to the designers. However, as we mentioned in our development on the intermediaries and boundary objects, the cognitive dimension of the representation should be carefully supported if we want to talk about shared representations. In that case sharing graphics appears insufficient as many other aspects of design are shared through common language. Supporting the designers' discourse cannot be avoided.

Some attempts have been made to record and store video and audio minutes of design minutes [16] in order to grasp the discursive dimension of design. Our approach is slightly different and considers that the participant must be active in the process of eliciting there arguments in order to foster the enrichment of the transactive memory. So the argumentative thread (remember fig. 7) is to be filled by the participants themselves. The main effect of that is that the participants remember what they have done during the asynchronous argumentative phase and come back naturally to the discussed points during the meetings. This is a major point in the process of creating a shared understanding if we adopt a process perspective- as we have discussed in section 2.2.

6. CONCLUDING REMARKS

In this paper we tried to support the idea that an effective design communication should rely on both an efficient object sharing system and an efficient argumentation based system. Both perspectives should be equally considered. The graphical and non verbal aspects are of prime importance especially during early design phases where ideas must be expressed in a very concise way. But on the other hand, many aspects can also be expressed through our natural language, particularly when people express requirements, constraints or limitations of the current design solution. We do not want to oppose the two ways of expressing ideas or arguments, rather our aim in this paper was to support the idea that the two communication modalities are complementary and should not be considered separately. This opens many research perspectives in terms of computer aided design communication tools.

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