Viewpoint Management for Cooperative Design

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ABSTRACT

This paper aims to make intelligible some important notions such as « Viewpoint » and « Correlation of Viewpoints » and to show the necessity to take into account these notions in order to analyze any cooperative design activity or to support it. After a brief introduction, Section 2 describes our model of Viewpoint based on an argumentative approach of the design activity and five types of Design Viewpoints. Section 3 introduces our model of correlation between design viewpoints. Finally after a short state of the art in section 4, Section 5 concludes first on the importance of taking into account the heterogeneity of a group of users, in particular, their viewpoints in « design groupware » or more generally in Computer-Supported Cooperative Work (CSCW) and, secondly on future work.

1 INTRODUCTION

Cooperative Design concerns the design of complex systems (satellites [23,10], cars, complex software such as CAD tools [24,25], etc.) where the designers have to create together an artefact or a product [21]. By cooperation, we mean as well as the tasks executed by the agents than the *definition* and the *orientatio*n of these tasks.

Indeed in order to cooperate in designing complex systems, it is not enough to communicate or transmit information (meetings, email...), to have common goals, to classify and execute design tasks or to use collectively some resources in order to obtain a certain goal but they need to share knowledge of their activity - in fact as early as possible. Indeed the most difficult task for designers co-operating is to find a common framework where they could communicate in order to create, share or transmit their knowledge on a same problem to be solved. In fact their knowledge is expressed according to their different backgrounds, the different practice communities they represent but also to their private viewpoints during the design process.

The main problem in Cooperative Design is therefore to correlate, whenever it is possible, their viewpoints (we call it a problem of *«correlation of viewpoints»).* By *viewpoint*, we mean the concept of isotopy as introduced and defined by Greimas [12] (with the difference we don't use it in a static way but linked to the design process) i.e. for us, the thematic referential referred implicitly or not by the designer during his argumentative activity. So correlation of viewpoints means that designers accept to work according a new knowledge organization - result of their argumentative operations during their common tasks in the design activity.

We aim in this work a better understanding of viewpoint management in cooperative design, in order to

- to better identify the computer-supported cooperative tools useful for designers in their collective activity,
- to better guarantee the appropriateness of such tools to an user-designer i.e. to better guarantee the information relevance given to an user designing according to a specific viewpoint at a specific moment ,
- to better identify the different elements related to the underlying viewpoints which are responsible of different past designs.

More precisely, our wish is also to support designers in finding such a common framework by first allowing the expression of their private viewpoints and secondly supporting the correlation of viewpoints in different contexts in cooperative design, such as the argumentation process during a collective decision making [16,17] or the reuse of past design experiences [25].

The rest of the paper proceeds as follows : Section 2 describes briefly our Viewpoint model based on the assumption of five Design Viewpoints and Section 3 deals with the correlation of Design Viewpoints. Throughout Sections 2 et 3, we refer to a real example of a collective design activity in satellite design at CNES company, more particularly to some results of our CNES protocol analysis we made in 1995. Section 4 presents

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the main related works. Finally, Section 5 highlights the importance of taking into account the heterogeneity of knowledge in a group of designers for CSCW in Design or more generally in « design groupware » and concludes on our future works.

2. DESIGN VIEWPOINTS

In order to take into account the heterogeneity of a group of designers and to support the organization of design knowledge, we propose a Viewpoint model, based on an argumentative and topical approach [22] and inspired from Aristotle. Then we illustrate it by some results of our protocol analysis in cooperative design in satellite engineering.

2.1. Viewpoint Model

We propose in our model five types of design viewpoints (or design isotopies) based on our understanding of design issued from our experiences of implementing AI-based prototypes in design [23,24] and the assumption of the existence of five philosophical meanings of the concept of Design which is based on the "four causes or conditions of the production of things" of Aristotle and on Farabi's work (see [18] for more details on the roots of this assumption).

1 - **Work** (related to efficient cause) noted by the letter **W**;
2 - **Fashion** (related to the formal cause) noted by the letter **F**;
3 - **Purpose** (related to final cause) noted by the letter **P**;
4 - **Esthetic Form** (related to material cause) noted by the letter **E**;
5 - **Representation** (related to the « fifth » cause of the quintessence [18]) noted by the letter **R**.

We argue that we can find these five types of isotopies (or viewpoints) in any design of complex systems. (see [18] for the roots of this hypothesis). *For example, a designer*

W – (1) designs/ plans to DO X;
F – (2) in order to create/ product a HOUSE;
P– (3) conceived and realized in order to serve a FAMILY;
E – (4) (and to give the feeling) of a nice HOME;
R – (5) (and who) shows/represents with a schema or a PLAN.

Although, the design activity needs all these five design viewpoints, some design communities give more importance to one viewpoint than another. For example,

W - (1) Some designers are more interested in the design process (problem solving model, scientific or technical knowledge useful in the design process, technological or economical resource allocation, design management, etc.);

F - (2) Some focus more in the physical or technical quality of products to be manufactured (quality, product life cycle, performance, etc.) and their environment;

P - (3) Some prefer the effects the artefact might produce on the future users (ergonomics, ecological effects, global evaluation of the effects, etc.);

E - (4) Some designers are more involved in formal or aesthetic quality of products (« design », form, color, attractive products);

R - (5) And finally others focus more in the power of different representation modes during the design process (scheme, draft, mock-up, flow-chart, CAD tools).

Figure 1 presents an example of a structured view of these five type of design viewpoints.

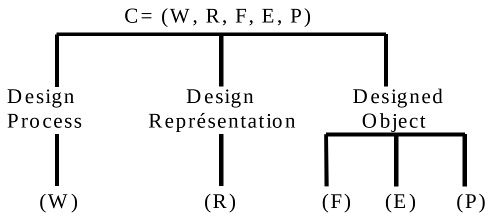

Figure 1: Structuring the five Design Viewpoints

For each Design Viewpoint (W,R,F,E,P), we could define a hierarchy of isotopies first with different shared isotopies in a specific domain and/or application and secondly, for each shared isotopy, private isotopies (or viewpoints) of the designers.

2.2 Illustration in satellite design

We illustrate here how we analyze the constitution of a isotopy for a given designer from our CNES protocol retranscription. Such a semic constitution of one isotopy concerns the organization of its inherent attributes with three identified methods[2]. Our protocol analysis method lies mainly on the sentences significant of an (explicit or implicit) argumentative process or a topical reasoning in the discourse : for example, the orientation of a sentence by using some connectors such as « but » is very revealing for us an *implicit* argumentative topical reasoning. In fact, our protocol analysis method is viewpoint-based oriented and guided by some hypothesis issued from our Viewpoint model. Our method consists briefly first in the following steps.

First, we try to identify topical reasoning and gradual relations in the protocol retranscription i.e. the use of topoï [3,22] in the argumentative parts of the discourse such as *« More an object X has a propertyB, More an object Y has a property B »* (or *More ..., Less ...*, etc.). Then we identify the properties or attributes (or topical fields) involved in these topoï and classify them in the five design viewpoints according

For example, we identify the following gradual relation in the discourse of the agent C, « More the structural coefficient of the satellite increases, less it makes the design of such a satellite easy ». The attributes structural-coefficient[satellite] and easiness[design] are classified respectively in the isotopies F and W. And the above relation corresponds to a F->W topical inference (cf. others types of topical inferences in Figure 2).

Let us note that the classification of attributes is not an easy task for the analyst because he has most of the time to interpret and retrieve some contextual information:
For example, the « cost » attribute used by an agent might be classified as an attribute belonging to the isotopy W (as manufacturing cost) or to the isotopy F (as quality cost).

Secondly, we account the attributes for each of the five Design Viewpoints and by each designer during the whole design

[2] These methods are not described in this paper due to the page limitation : they concern the elucidation of the links between all the attributes inside one isotopy.

activity, during each design task or design time period. For example, Figure 2 shows some results issued from our protocol analysis related to the three agents (noted A,B and C) of the design activity in satellite design. Table 1. represents such an account of attributes by isotopy for each designer (A, B or C) during their whole activity.

Agent	***E***	***F***	***P***	***R***	***W***	***Total***
A	0	45	1	0	25	**71**
B	0	14	1	3	20	**38**
C	3	3	9	2	35	**82**
Total	**3**	**92**	**11**	**5**	**80**	**191**

Table 1: Isotopies referred in topical reasoning

Figure 2 shows for the designers A and C the number of topical inferences (extracted from the protocol) of each type such as F→W, W→F, W→P, etc.

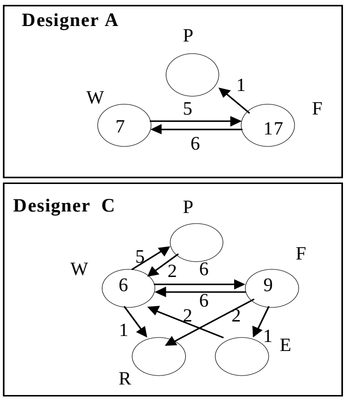

Figure 2: Topical inferences and isotopies

According to such results, we check some hypothesis linking the viewpoint(s) activated by the agents involved in a cooperative design activity and their skills and/or backgrounds.

For example, the designer A has the isotopy F as his prevailing design viewpoint and as the location of his prevailing argumentative reasoning, which suits perfectly to his skills of technical engineer. The designer C has no clear prevailing isotopy among all the five used design viewpoints and his prevailing argumentative process is not located inside a particular isotopy as the agent A but between the five design viewpoints, which suits also to his « manager » position.

3. CORRELATION OF VIEWPOINTS

Our aim is to understand the constitution of the correlation(s) of dynamic viewpoints: so we address here the constitution of the relations between isotopies themselves and no. the constitutive nature of one isotopy (addressed briefly in section 2.2). After introducing our approach, we present first the main elements of our model of correlation of dynamic viewpoints which are illustrated by some results of our study in satellite design.

3.1 Our approach

We view the correlation of viewpoints according to the cognitive attitudes of designers [21] and based on their topical reasoning according to Aristotle (*Rhetoric* and also *Organon* - V -*Les Topiques*). By topical reasoning, we mean the triple aspect as following: 1) Topical reasoning is very often viewed as gradual inference or category-based inference. The topical problem is first viewed as a reasoning problem; 2) But topical reasoning with its expression looks forward influencing the audience, in fact it is an argumentation looking forward influencing the viewpoint of another; 3) Such an influence may have different goals whose one of these aims to deliberate or to express a preference concerning what is is useful (or more or less useful). Now topical reasoning must be considered the most convenient to the contexts requiring a deliberation. We don't focus in our work about the correlation of viewpoints on the dimension of communication as Grice does in [13] but on the inference and deliberative dimensions of a cooperative work in design.

3.2 Four Elements for the Correlation of Viewpoints

To model the correlation space or to elaborate our model of correlation of dynamic viewpoints, we deal with four main problems:

a) the nature of the topical skills of the designers;
b) the interaction spaces corresponding to the topical skills;
c) the way to take into account the significant factors inside the interaction spaces;
d) the description of the extern and intern historical record for each isotopy of the argumentative space during each time period (design step) or a group of time periods (corresponding to a task) of design problem solving.

a) Three Topical Skills: we distinguish the three following topical skills.

- *Inference skill:* it corresponds to the logical aspects of the topical reasoning, this reasoning is expressed as gradual relations or category-based inferences.
- *Social skill:* it refers the designers' attitudes in their discourse with somebody else; more generally it concerns the pragmatic aspects of the communication between designers, i.e. the expressive aspect of the designers' discourse is important. We take into account the « speech » of the designer and how they transmit their consensual or not degree for example toward somebody else. The topical reasoning here looks forward influencing the others agents.
- *Deliberative skill:* this skill is not related to the logical-semantic or communication skill but to the reasoning linked to what it is useful in a collective problem solving. Here the argumentation as a deliberative skill doesn't consist in finding the right scientific or technical answers specific to a given problem but also in knowing to make the right choices in situations which need a trade-off, according to an « utility » criteria as the justification of these choices.

b) Three Interaction Spaces: we start with the hypothesis that for each previous skill corresponds a view of the cooperation space i.e. a specific interaction space (or argumentative space) in which this skill is intelligible. We focus then on the three interaction spaces corresponding to the three skills (cf. Figure 3) and also to the three signification spaces for the analyst agent.

- The interaction space in which are expressed the inference skills is called **argumentation space Sa.**
- The interaction space in which there are the social skills is called the **communication space Sc.**

- The interaction space in which there are the deliberative skills or the skills useful for working in the problem solving is called the **problem solving space Sps.**

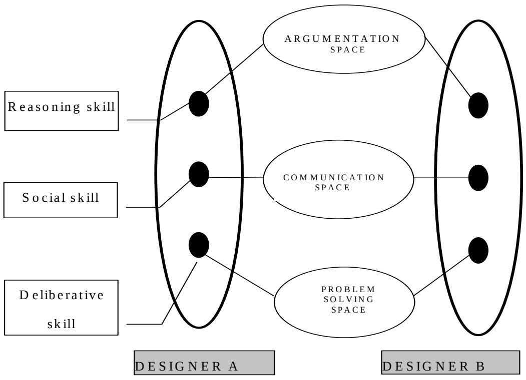

Figure 3: Three views on the cooperation space

The next problem is to link these results of these three skills inside a same space which we called the correlation space**.**

3) Significant Factors and Correlation Space: in our argumentative approach, the five isotopies are identified to viewpoints and also considered as five common places. The question of correlation is therefore to decide (cf. Figure 4) if (a) one of those viewpoints is prevailing from a global analyst's point of view and (b) if there is a clear collective step in the solving problem space which (c) both agree (more or less) with the topoï produced by individual designers.

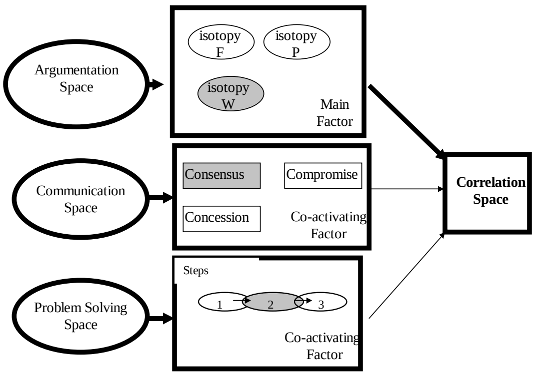

Figure 4: Correlation space

4) Historical Record of a Prevailing Isotopy or Relationships between Isotopies: we address here the extern historical record of the prevailing active isotopy in the argumentative space during a specific design step. It means the relationship among three identified ones (coordination, subordination and translation) this isotopy keeps with the others isotopies.

1) In this paper, we just illustrate what we call <u>coordination</u> via an example issued from [18] (page 27).

« we can tackle the agreeable aspect of this product (attribute of the isotopy E) because it is easy to do (attribute of the isotopy W). » Here the « agreeable » attribute of the isotopy E is viewed from the attribute of the isotopy W (i.e. «easy»). These two attributes are not considered as contradictory but nevertheless it is the isotopy W which plays the role of coordinator of the others isotopies and more particularly the isotopy E.

2) The principle of subordination between isotopies is by nature destructive in the Topical Theory: it expresses the power of an attribute of one isotopy to unify in a whole all the attributes of the others isotopies.

3) The principle of translation inside one isotopy (ex: W1→W2) or from one isotopy to another one (ex: F→W) can create a new referential site for the designers and then can generate a new isotopy under the condition to be validated in the future by the designers.

3.3 Our Model of Correlation of Viewpoints

In our model of correlation of viewpoints, we deal first with <u>two</u> interaction spaces: the argumentation space and the problem solving space i.e. we deal with both topical and problem solving dimensions of the discourse (c.f. section 3.1). This can be extended in the future to the correlation over a Communication Space (to cover the negotiation dynamics). Figure 5 illustrates what we call « cooperation space : it shows how the individual isotopy W is hold by the group as a collective isotopy and how the step 2 acts as a context for the correlation of the others active isotopies to the prevailing isotopy W.

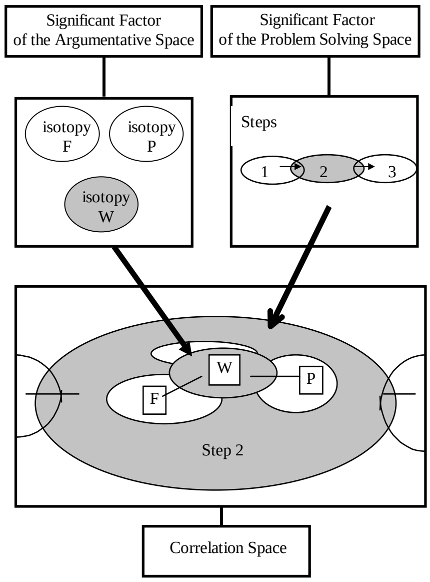

Figure 5: Our approach of the correlation space

Our model of correlation of viewpoints deals also with dynamic viewpoints. For this, we propose two modes of modification of a prevailing isotopy during the problem solving i.e. from a step to another one.

- The first mode concerns the study of the way a prevailing active isotopy is modified during the problem solving. The term « modified » must be interpreted as a collective emergence of a new viewpoint (ex: W1 → W2 or ()→ W).
- The second one concerns 1) the change of perspective (i.e. when the prevailing isotopy goes up from the isotopy X to the isotopyY) and also 2) the change in the extern historical record of the prevailing isotopy from one step to another one, i.e. when the relationships between the prevailing isotopy and the others active linked isotopies change from one step to another one.

3.4 Illustration of Correlation of Dynamic Viewpoints

Based on such a definition of the correlation space, we have developed an analysis method of correlation of dynamic viewpoints which consists briefly first 1) in identifying active isotopies in the argumentation space, secondly 2) in identifying the design step as co-activating factor in the problem solving space and finally, 3) in identifying if there is a change in terms of prevailing active isotopies compared to the last design step in order to conclude on the change of perspective (ex: P→W) or the change of relation (ex: Wr1→Wr2, here the relationships between the prevailing isotopy W and the others active isotopies change from one step to the next one).

In order to illustrate our purpose, *Figure 6 shows the active isotopies during the « planning » task*[3] *(called « step3 » in Figure 6) and the F isotopy as the prevailing isotopy.* This result is always based on the account of topical inferences and the classification of their topical fields. Like this, we could analyze the isotopies prevailing in each task (or time period etc.) as well as their extern historical record.

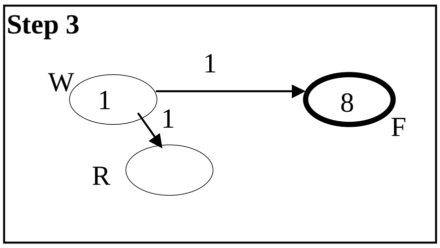

Figure 6: Viewpoints in step 3 in satellite design

Like this, we could conclude on some emergence of viewpoint or some change of perspective/relation.

For example, at the beginning of the activity in satellite design i.e. in the « problem statement » task, there is no prevailing isotopy. Then in step2 (i.e. the « problem construction » task), there is the emergence of a collective viewpoint with the prevailing isotopy W. The prevailing isotopy goes up from the isotopy W in step 2) to the isotopy F in step 3 (i.e. the « planning » task). We observe here a change of perspective *from step 2 to step 3 (W→ F). More another result of our analysis is that the isotopy F in step 3 co-ordinates the two others active isotopies.*

4.. RELATED WORK

Viewpoints or Views have been the focus of research in various well-established areas [6], more or less explicitly: computer science, semiotics [6], linguistics [3], cognitive psychology. We can cite, for example, in computer science and artificial intelligence: 1) object-oriented databases (e.g. [1]) and object-oriented languages (e.g. [5]) where the main motivations to introduce views or viewpoints are either to represent shared views on a predefined object (a viewpoint is a sample filter) or to solve some multi-inheritance problems in object-oriented languages. 2) Most of works in object-oriented representation (e.g. [19]) concern shared views or viewpoints. 3) In distributed artificial intelligence (DAI) applied in Requirements Engineering for complex software design (e.g. [8,9]), the use of viewpoints is to organize multi-perspective software development (knowledge) and particularly to manage inconsistency. In cognitive psychology, the concept of Viewpoint is not explicit but could be related to mental representation in the sense that it concerns knowledge useful to produce different mental representations in a specific problem solving activity.

The originality of our work consists mainly in the four following points.: 1) First, we deal with private viewpoints of human agents when most of the previously cited works deal with shared viewpoints/views; 2) Secondly, our approach of viewpoints deals with argumentation and more generally with the problem solving activity process when most of the works adopt a static approach of the notion of viewpoint. 3) Thirdly we use a qualitative and semantic approach of the notion of correlation unlike the more classical approaches such as statistical approaches; 4) And finally our approach is dedicated to Design and based on five Design Viewpoints (related to the five philosophical meanings of Design [18]) which facilitates the organization of design knowledge/information inside an enterprise memory or a technical memory .

5. CONCLUSIONS

Our conclusion concerns the interest of such a work or a Viewpoint-based activity model for CSCW and more precisely for « groupware » in design – what we call « design groupware » – Classically three criteria are used: the synchronization, the geographical location and the number of users (or size). According to our point of view, we must add to the three classical criteria used in groupware a fourth criteria related to the heterogeneity of the group of designers (cf. Figure 7) if we intend to really support them.

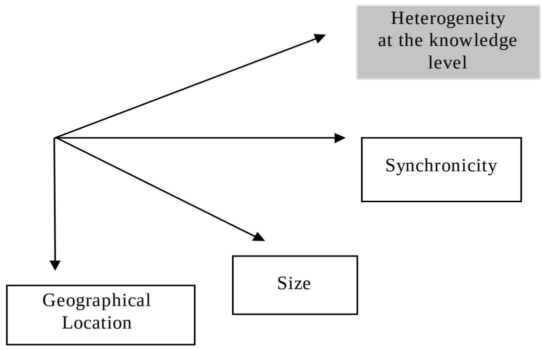

Figure 7: Four criteria for Design Groupware

We intend the notions of « viewpoint » and « correlation of viewpoints » to be central 1) for the analysis of a complex design activity (in particular for the manager of design projects), and 2) for the specification and the design of real tools supporting designers during their cooperation, whatever their cooperation

- is direct (for example by making collectively decisions, see CSCW [11], Decision Making Support Systems [17]),
- or indirect (for example by reusing past experiences of others designers [25]).

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[3] In fact we identify first the main tasks of the design activity and secondly the different time periods for each task. We use the term step 3 instead of the « planning » task.

The question is now related to the easiness of acquiring and modeling viewpoints and correlation of viewpoints, this task is easier than knowledge acquisition required for knowledge-based systems. Here we need only Viewpoint acquisition. We believe that designers could do it easily supporting by a viewpoint modeling tool based on such a model and then, become – what D.A Schön called in [20] – « reflective practitioners » or could work successfully on - what we have mentioned in [10] - the elucidation project of their design project (see [10] for more details on these two projects).

Future work on « viewpoints in design » concerns first further formalisation of our Design Viewpoints framework and notions of inconsistency, secondly the design and the implementation (written in Java) of such a framework related to Design Viewpoints and finally its use in design for two types of applications on the Web aimed by the AID Research group at INRIA: 1/ cooperative information retrieval [15] and 2/ argumentation and group decision making [16,17].

6. REFERENCES

[1] S. Abitboul, A. Bonner. *Objects and views,* in Proceedings ACM SIGMOD Symposium on the management of data", 1991

[2] Workshop notes on *« The Nature and Role of theory in AI in design »,* In International Conference on « AI in Design » (AID'94), Swiss federal Institute of technology, 1994

[3] J.C. Anscombre, O. Ducrot, M.M. Garcia Negroni, S.Palma, M. Carel. *« Theory of topoï » (in French),* Edition Kimé, Paris, 1995.

[4] T. Brinck. *CSCW & Groupware.* http://www.crew.unich.edu/~brinck/cscw.html

[5] B. Carré, L. Dekker, *Inheriting Object-Orienting Features through Meta-Programming - a Frame Extension To Rome*, Proceedings of East Europe'91 Conference on Object Oriented Programming, Bratislava, September 1991.

[6] P.J. Charrel, B. Rothenburger, B. Trousse et C. Vogel. *« State of the art on Viewpoints in Semiotics, Linguistics and Computer Science (in French)»,* Document CNES, ref. D1.1 de la R&T: Study of Dynamic Viewpoint, Contract CNES/ INRIA 871/94/CNES/1492 , 1995.

[7] A. Dix. *Challenges and Perspectives for Cooperative Work on the Web*, Proceedings of the ERCIM workshop on CSCW and the Web, Sankt Augustin, Germany, 1996.

[8] S. Easterbrook. *Domain Modelling with Hierarchies of Alternative Viewpoints*, In Proceedings, First IEEE international symposium on Requirements Engineering (RE'93), San Diego, 1993.

[9] S.M Easterbrook, E.E. Beck, J.S. Goodlet, L. Plowman, M. Sharples, C.C. Wood. *A Survey of Empirical Studies of Conflict,* In S.M. Easterbrook (ed.), CSCW: Cooperation or Conflict? , London: Springer Verlag,, pp. 1-68, 1993.

[10] D. Galarreta, B. Trousse. *Cooperation between Activities in Complex Organizations: Development Directions in Space System Design,* Design Journal of Design Sciences and Technology, 2(1), pp. 65-86, 1993.

[11] S. Greenberg. *Computer-Supported cooperative work and groupware: an introduction to the special issue*. International Journal of Man-Machine Studies, 34(2), pp. 133-141, 1991.

[12] A.G. Greimas, *« Pour une théorie de l'interprétation du récit myhique »*, Communications, 8, 1966.

[13]. A.P. Grice. *Logic and Communication*, In P.Cole & J. Morgan (eds) Syntax and Semantics, N.Y. Academic Press, 1975.

[14] J. Grudin. *CSCW: History and Focus*. .http://www.ics.uci.edu/~GRUDIN/CSCW.html

[15] M. Jaczinski, B. Trousse. *BROADWAY: a World Wide Web Browsing Advisor Reusing past navigations for group of users,* Proceedings of the 3rd UK case-based reasoning workshop (UKCBR'97), Manchester, UK, September 97. http://www.inria.fr/aid/papers/97ukcbr/ukcbr.html

[16] N. Karacapilidis, B. Trousse, D. Pappis. *Using case based reasoning for Argumentation with Viewpoints.* In D. Leake & En.Plaza (eds.) Case-Based Reasoning Research and Development, Proceedings of the 2nd Int. Conference on Case-Based Reasoning (ICCBR'97), Lecture notes in AI 1266, Springer Verlag, Berlin, pp. 541-552, 1997.

[17] N. Karacapilidis, B. Trousse. *Computer-Supported Argumentation for Cooperative Design on the World Wide Web*, In P. Siriruchatapong, Z. Lin & J-P. Barthes (eds.). Proceedings of the 2nd International Workshop on CSCW in Design (CSCWD'97), Bangkok, Thailand, November, International Academic Publishers, Beijing, pp. 96-103, 1997.

[18] T. Orel, B. Trousse. *A View on the "Philosophical" Meanings of the Concept of Design,* In International workshop on "Philosophy of Design and Information Technology", Caen, 1994 & In the international of Design Science and technology, 4(1), pp. 9-28 , 1995.

[19] O. Marino, F. Rechenmann, P. Uvietta, *"Multiple Perspectives and Classification Mechanism in Object-Oriented Representation"*, In Proceedings of the European conference in AI (ECAI'90), Stockholm, 1990, pp. 425-430.

[20] D.A. Schön 83. The *Reflective practitioner*, Basic Books, New York, 1983.

[21] H. Simon. The Sciences of The Artificial, 2nd edition, The MIT Press, 1981.

[22] B. Trousse, H.C. Christiaans. *Design as a Topos-based Argumentative Activity: a Protocol Analysis Study*, In N. Cross, H Christiaans & K. Dorst (eds.), Analyzing Design Activity, John Wiley & Sons, pp. 365- 388, 1996.

[23] B. Trousse. « *Cooperation between knowledge-based systems and CAD tools: the multi-agent environment ANAXAGORE* », « Thèse de doctorat » of the University of Nice, December 1989.

[24} B. Trousse. *Using AI in complex system design: implications on building ICAD tools*, Special issue AI/CAD of the International Journal of CADCAM and Computer Graphics, Hermes, 8(3), pp 303-336, 1993.

[25] B. Trouse, W. Visser. Use of Case-Based Reasoning Techniques for Intelligent Computer-Aided Design Systems, In proceedings of the IEEE Int. Conference on Systems, Man and Cybernetics – Systems Engineering in the service of Humans, Le Touquet, France, pp. 513-518, 1993.