Aggregation Method to Reuse Knowledge from Project Memory

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ABSTRACT

The knowledge engineering offers a rational framework allowing a representation of knowledge obtained through the experiences. This technique found a great application in knowledge management and especially to capitalize knowledge. In fact, the rational representation of knowledge allows their exploitation and their re-use. It is a necessary condition to allow a re-use and a knowledge appropriation. The knowledge management must take into account this dimension, since its first concern is to make knowledge persistent, ready to be re-used. In this paper, we study the traces classifications of the design project achievements in order to have a knowledge aggregation and to thus provide a representation of handled knowledge, directives and competences organization as well as negotiation strategies and cooperative problems solving.

Keywords

Knowledge management, project memory, classifications, cooperative problem solving

1.0 INTRODUCTION

The knowledge engineering offers a rational framework allowing a representation of knowledge obtained through the experiments. This technique found a great application in knowledge management and especially to capitalize knowledge. In fact, the rational representation of knowledge allows their exploitation and their re-use. It is a necessary condition to allow a re-use and a knowledge appropriation. Behaviour laws provide strong semantics to observe as well as an argumentation of this behaviour, ready to be reproduced to solve new problems (Richard, 1990). The knowledge management must take into account this dimension of knowledge, since its first concern is to keep a persistent knowledge, ready to be re-used and adapted. In this paper, we present, a form of knowledge management, keeping track and capitalization of project knowledge. This memorizing follows two essential steps: a project traceability (Bekhti & Matta, 2003) and a knowledge capitalization.

The traceability makes it possible to keep track of the episodical memory in which space-time associations of events are described (Karsenty, 1996). Project Memory is a form of this memory where cooperative problem solving and their context are represented. These events are a source for epistemic constructions, intended to build interpretations (Richard, 1990) which can be represented in the semantic memory.

Classifications of these tracks can be made. These classifications can be guided, either by a structure of representations and / or by typologies and generic knowledge.

We try to reproduce this step to represent the "collective" knowledge of organization. Indeed, the situations of problems solving arise through the projects. A traceability and a structuring of these projects "context and design rationale" provide a knowledge asset structured by situations problems. These various situations must then be analyzed to identify cooperation strategies as well as the knowledge handled by the organization. We will thus obtain a representation of the body "knowledge handled", directing actions "and competences of the organization" and behaviour laws “negotiation strategies and cooperative problem solving". Classifications can be based on similarities of events and hierarchy aggregation of concepts (type of problems, conflicts …). Here, we present this latter type of classifications.

2.0 PROJECT KNOWLEDGE

The realization of a project in a company implies several actors, if not other groups and companies. For example, in concurrent engineering, several teams of several companies and in several disciplines collaborate

to carry out a project of design. The several teams are regarded as Co-partners who share the decision-makings during the realization of the project. This type of organization is in general dissolved at the end of the project (Matta et al., 2002). In this type of organization, the knowledge produced during the realization of the project has a collective dimension which is in general volatile. The documents produced in a project are not sufficient to keep track of this knowledge which even the head of project cannot explain. This dynamic character of knowledge is due to the cooperative problem solving where various ideas are confronted and with a cooperative definition of the produced solution.
A project memory describes "the history of a project, the experience gained during the realization of a project" (Matta et al., 2002). It must consider mainly:

- The project organization: different participants, their competences, their organization in sub-teams, the tasks which are assigned to each participant, etc.
- The reference frames (rules, methods, laws ...) used to carry out the various stages of the project.
- The realization of the project: the potential problem solving, the evaluation of the solutions as well as the management of the incidents met.
- Main goal of the project: the negotiation strategy which guides the making of the decisions as well as the results of the decisions.

The project memory contains knowledge regarding the context as well as the problem solving or design rationale. The structure of this memory can then be organized in two points, context and the design rationale.

The context represents:

- Organization of a project: the process and sequencing of the activities, actors implied with their role in the project and their competences;
- Working environment: methods, techniques and tools used, objectives, requirements and constraints, references, procedures qualities, standards, directives and rules.

The design rationale describes mainly:

- Encountered problems: description and classification;
- Problem solving: proposed solutions, argumentations, decisions.

Often, there are interdependence relations among the various elements of a project memory. Through the analysis of these relations, it is possible to explicit and to make relevance of the knowledge used in the realization of the project. Fig 1 presents an outline of this type of relations.

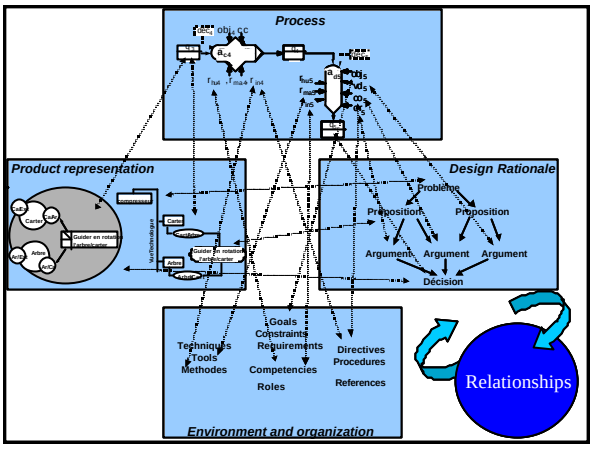

Figure 1: project memory organization

The traceability of this type of memory can be guided by design rationale studies (Karsenty, 1996). In the same way, work in knowledge management study techniques of traceability and definition of project memory (Bekhti, 2003), (Matta et al, 2000). In this paper, we propose to study classification of project track as a mean to capitalize the organization knowledge.

3.0 CLASSIFICATION

Classification consists in gathering various objects (individuals) in subsets of objects (classes). It can be supervised where the classes are known, they have in general an associated semantics (Diday, 1984), or not supervised where the classes are created via the objects structure, semantics associated with the classes are then more difficult to determine (Nack et al, 2000). In both cases, we need to define the concept of distance between two classes, which will be made by the means of criteria; these criteria of aggregation will be explained thereafter. Classification methods form part of the whole of the multidimensional descriptive methods, and their purpose is to clarify the structure of a whole (in our case, tracks of design projects). The main objective of the classification methods is to distribute the elements of a whole into groups, i.e. to establish a partition of this unit (Jain & Dubes, 1988). Several constraints in the form of assumptions are imposed and validated progressively, each group having to be the most homogeneous possible, and groups having to be the most different possible between them. The classification methods clarify the structure of an important data entity. It is then possible to classify a whole group of individuals who make it up, characterized by similarities criteria (Johnson, 1967).
There are many methods of classification, and we only present, the most adequate for our work, and one can distinguish 5 types of methods of classification suggested in the literature (Benzecri, 1973).

1. Hierarchical classification: Where hierarchy is obtained either by an agglomerative (upward) method, maybe by a divisive (or downward) method.

2. Classification by partition: Where the number of classes is fixed at the beginning: the aim is to gather N individuals in K classes. The individuals must similar and the classes must be separate. It makes it possible to treat sets of relatively high manpower by optimizing relevant criteria.

3. Method of the densities: it seeks, in the workspaces the high density zones if they exist.

4. Fuzzy classification: Method providing by the means of algorithms of the not disjoined classes (encroaching).

5. Analyze factorial Q-SORT: Based on the spectral decomposition of matrix XX' where X, of dimension (N,P), is the table of figures containing N individuals to be classified.

We chose the hierarchical method which is defined as a search for a valued hierarchy, or also a hierarchical classification (hierarchical clustering) (Chavent et al, 1999). Such a research is based on a concept of distances between individuals or objects (elements of classification) which induces a measurement of the heterogeneity of a part based on the distances among individual objects which are in a class and a measurement of dissimilarity between two parts based on the distance between an individual of a class (i) and another individual of another class (j). Moreover, one is not satisfied with a simple partition, but one seeks a hierarchy of parts, that constitute a tree. (Benzecri, 1973). In our case, we would like to establish causal relations (explicitly or implicitly) between the concepts of the preliminary project memories (the suggestions, discussed arguments, the competences, the nature of the task, initial knowledge on the problem, their kinds, the number of participants and their roles) and aggregations criteria which one will call dependent variables (the sociological criteria, psycho-cognitive, and relating to co-operative work), in order to define aggregation strategies, that can be summarized as follows:

Criteria! Concepts (Strategy R).

4.0 PROCESS OF AGGREGATION

Our aggregation process follows a number of steps and functionalities in order to allow firstly an enumeration of all the concepts, and secondly the use potential of regrouping mechanism of the project memory concepts. This allows to facilitate the re-use, the interpretation and reading of knowledge intervening within the framework of the design.

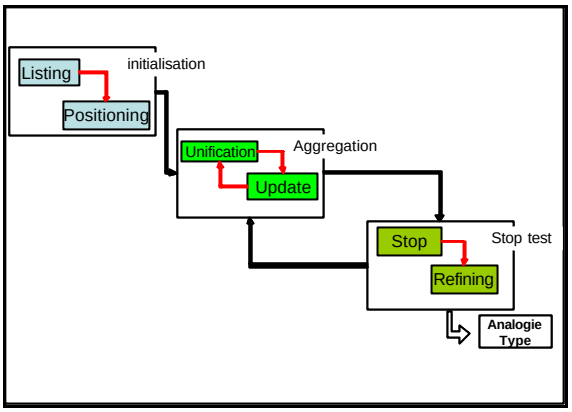

Figure 2: Architecture for knowledge concept aggregation

- The initialization phase: it links two sub-phases which make it possible to support the concepts emerging during the meetings of projects, it consists, amongst other things, to give a micro view of the meetings of the project by peeling off all these elements (concepts) and by making the first separation, to be able to distinguish the aggregation thereafter.

  • Listing: listing all the concepts of the project of design, all participants' arguments or suggestions, as well as the decisions, to try thereafter to see possible separations: distinct problems, tasks not implying the same resources, participants not carrying out the same tasks, arguments…

  • Positioning: identifying the provisions of the concepts, those which can be gathered, for example, arguments with the suggestions corresponding to a participant... Then to build a starting grid, which we will call thereafter matrix of aggregation.

- The phase aggregation: it will contain two sub-phases which will be much more functional. The first phasewill be gathering informationsand the second will update the matrix. The concepts are bound by a similarity of selection criteria.

  • Unification: this process operates in the following way. if the criterion characterizes the same concepts, then they must be gathered, while taking as a starting point the hierarchical methodology of classification. We defined strategies of aggregation based on criteria. That we will present in (paragraphs 4.1).

  • Update: this sub-phase of aggregation, will allow bringing up to date the matrix, to saying that the gathered segments will be unified under the same criterion.

- The stop phase: We proceed in an iterative way until obtaining classes:

  - Stop test: if there is not any more concept to be gathered, or if the criteria are not valid any more (criteria available and non-active to carry out gathering) then continue to the following step, and stop the process.

  - Refining: to name the classes and to verify redundancy.

We chose to illustrate our approach using an examples, extracts from a cooperative platform of discussion ACSP (Gomes et al, 2003) allowing the joint work of the actors or participants of a project of design. We could recover a corpus of exchange of meeting (several meetings, exchange of mails, and interaction) of the design of a wind power plant. We did not study the whole of the interactions yet, and we thus use this example simply as illustration.

4.1 Criteria of aggregation

It should be noted in this paragraph where we will present the criteria of aggregations of our process of classification, that several criteria can be released according to various aspects of the study of the cooperation and the negotiation in a project: sociological, psycho-cognitive and cooperative work.

4.1.1 Criteria from the sociological point of view

"Among the various types of communicative interactions which can be produced in situations of group, it is noted that the argumentative and explanatory interactions are particularly favourable with the Co-development " (Beaker, 2004), in addition to "the multiple relations which exist between the explanation and the argumentation" (Plantin, 1996), "the first dimension (the explanation): corresponds to the degree of subdivision of the responsibilities for the realization for the tasks for the problem solving in the organizations "(Ducrot, 1982). In other words, it acts as the spontaneous distribution of the work of co-operative problem solving. These tasks relate on the one hand the problem to be solved, and on the other hand, the activity to cooperate with itself (Baker, 2004), in and by the dialogue. When the responsibilities for the realization for these tasks are assumed spontaneously by the participants in a relatively stable way through the interaction, one will describes sociological criteria consequently depending on the task of the problem to solve parts played by the participants and of the arguments advanced (Conein et al., 1992). In these studies, we can propose, concept of organization of the tasks and argumentative and explanatory interactions.

The argumentative criteria allow interpretation, vision and evolution of the suggestive arguments; one urrently can distinguish 5 types (Beaker, 2004; Plantin, 1990; Toulmin, 1984; Ducrot, 1982):

1. Dialectical criteria types: to strongly bind to the argumentative play of intervention such as attacks, defence, counteract.
2. Evolutionary criteria types: evolutions of attitude noted at the time of discussion such as for, against, neutral.
3. Epistemological criteria types: the nature of knowledge concerned in the dialogue, origins and the perceptual plans (how knowledge and perceived by the various participants)
4. Conceptual Criteria types: how universe of reference and conceptualized, evolution of the concepts concerned.
5. Interactive criteria types: approach the cognitive-linguistic, transformations (reformulation).

On another plan, the distribution of the tasks and the roles can be symmetric or asymmetric. The distribution is symmetric in case, the role will assume completely and globally the task, and conversely for the asymmetry role / task. Should the opposite occur this distinction reflects a clear vision for the later decision-making. It is to note that in this first approach we notice that the organizational approach (Basing itself on the actors, the roles, the visions and the group) favours the exchange by means of interaction and explanation in organizations, and it for the argumentation and the suggestion of the tasks for the cooperative problem solving.

The criteria of task can be distinguished on an organisational level throughout the evolution of the projects of design, knowing that a project of design forwards by three phases, we present the criteria below to bind to these phases:

Preparatory phase: imply two criteria types:

1. Criteria of specification: criteria to bind to the problems dealt with the implied participants.
2. Criteria of planning: strongly bound to time and the fixed stakes, for the problem solving.

Realization phase: it also puts two standard criteria

1. Criteria of execution: executive criteria which use average the techniques and human (taking part, their roles) and estimated tasks
2. Criteria of piloting: criteria of piloting of project putting the Masters of project (directing and development).

Phase of finalization: allows exposing criteria of feedback

1. Design criteria: criteria implying average technique, taking part, stake of time, …
2. Criteria of debriefing: feedback and analysis.
3. Criteria of filing: average technique, method of traceability, memory of project, data bases etc.

4.1.2 Criteria from the psycho-cognitive point of view

It was noted that research on distributed cognition, carried out in cognitive psychology these last decades, stressed the study of the acquisition of the procedures (Anderson, 1983), instead of the development of "comprehension" on the conceptual level. In the case of certain types of problems, the performance can be dissociated from comprehension: the participants can solve successfully without thorough control of the concepts concerned. However, in the case of the production of certain types of exchanges ("epistemic"), like the explanation and the argumentation, it cannot have such dissociation: competence and performance as regards explanations coincident (Ohlsson, 1996). The psychology-cognitive sight supports the individual aspect, which relates to participant and competence. We can distinguish from this study the criteria of the competence.

Criteria of competence, we have two types of competences functional competences related to the direct functions of the design project, organisational competences always related to the management of the project:

1. Criterion of execution: bound the execution of a task has.
2. Criterion of manufacture or creation.
3. Criterion of planning.
4. Criterion of management.
5. Criterion of piloting.

4.1.3 Criteria from cooperative work point of view

The study of the processes of collaboration must lie within a broader scope, that of a model of cooperative problem solving in and by the dialogue. A starting point impossible to circumvent is of course the "traditional" model of the individual problem solving (Darses, 1996), who will consists on the six following phases: the search for a problem, development of a representation of the problem to be solved, the planning of the solving strategies, the generation of possible solutions, the checking of the solutions, the feed back in order to integrate knowledge (reorganization of knowledge). In the case of a team, these stages integrate other criteria such as the roles and their evolution (change and modification) (Hermann, 2004), collaboration, interactions argumentative, conflicts, alliances of teams, negotiations. It should be noted that it is very probable that the cooperative problem solving in the projects of design, at a working group. A number of participative role one distinguished by PLETY (Plety, 1996), relations between these roles will come to be added to support a number of creation from knowledge based on the negotiation such as relations of the complementarities type/alliance/ conflict. The roles can be the objects of the implicit or explicit negotiations. (Plety, 1996) PLETY identified the four roles: Questioner, Verificator, independent and animator.
The role of the "Questioner" operates on the compromise plans and interdiscursifs (to ask the problem of the direction of the solution). The "Verificator" on the compromise level, against-argue the statements to push one second time the questioner to reargue his suggestion. The "Animator" on the international plan manages the exchange. "The independent" corresponds to a role more fluid than the others, or with the absence of a determined role, in a sociological point of view; it is passive, it does not interact for two reasons: it does not have competence necessary for a given task, or it is not concerned with the task. PLÉTY noticed that "the animator" and the "verificator" have a relation of alliance or competition: "they are not unaware of...". The true
cooperation occurs if the roles operating for problem solving and interaction. For example, to criticize a solution suggested by its partner, he checks the problem (the checking) and the interaction (to express its agreement or dissension compared to what it is proposed by its interlocutor). Criteria chosen from this point of view can be: Role, Interaction argumentative and taking part. Criteria of role (Hermann, 2004) as:

1. To assign: a role to a participant.
2. To take: catch of a role directly by a participant.
3. To offer: a role to a participant by a hierarchy.
4. To change: change of a role.
5. To define new: creation and definition of a new role.
6. Conflict of role: competition, opposition of participant on the same role.

We gathered these criteria to exploit them in the definition of the aggregation strategies.

4.1.4 Tree of criteria

In this section, we will present a summary of the criteria enumerated above in the three selected fields (Sociology, psychology-cognitive, Co-operative work). We have to gather these criteria in the form of tree while putting especially ahead: argumentative, task, role, participant and competence (Fig 3)

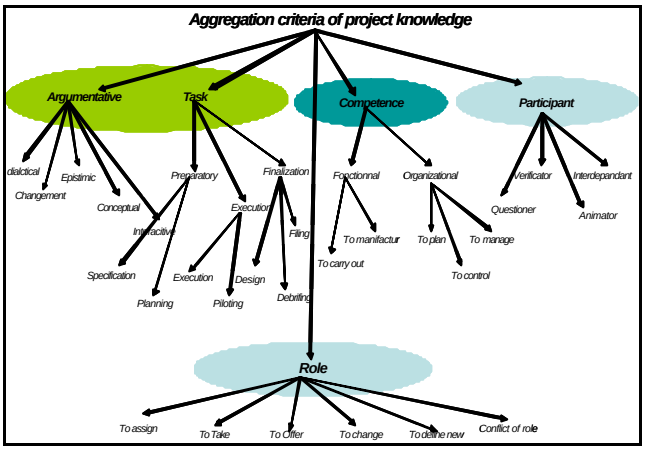

Figure 3: Scheme of tree criteria

4.2 Matrix of aggregation and strategies

We present in the form of a matrix the concepts which can be gathered under certain criteria; it is the result of the phase of the positioning of the process of aggregation (Fig 2).

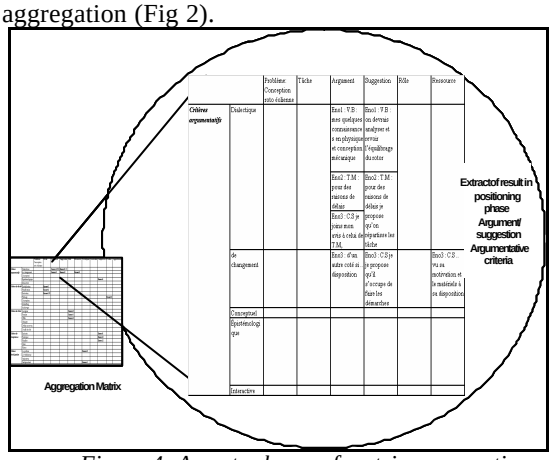

Figure 4: A part scheme of matrix aggregation

In this matrix, the lines represent criteria and the columns the concepts. The boxes of intersection will be filled by the statements extrated from the meetings tracks according to the concepts and the criteria. Thereafter we will build our aggregation strategies basing on this matrix.

Before announced diagram of the matrix, we propose some statements, extracted from one of the meetings held for the design of a wind mill, this example will help us to understand the aggregation process of the concepts.

Discussed problem: *the balancing of the rotor*

Statement 1: V.B.: *"we should analyze and re-examine the balancing of the rotor ourselves, and I should propose myself to do it, considering my knowledge in physics and mechanical design"*.

Statement 2: T.M.: *"for time reasons I propose that we distribute the task and I believe we should call upon technical consulting firm for the final design of the rotor as well as the problem which relates to the generator to be used"*.

Statement 3: C.S *"I agree with T.M., and I suggest that T.M. contacts the technical consulting firm but if a new manufacture of the rotor is required, V.B. should take care of it, considering his motivations and his materials"*.

4.3 Aggregation Strategies

Traceability allows keeping track of situations of cooperative problem solving and emphasizing characteristics of these situations. The capitalization of knowledge which we recommend is based on the similarity of these characteristics to make explicit the strategies learned by the organization through these projects.

To define aggregation strategies allowing this classification, we proceed by stages according to the process of aggregation presented (paragraph 3):

The listing phase, for example, according to the discussion on the design of the wind mill: Argument "my some knowledge, for reasons of times ", Competences "physics and mechanical design", Try "to analyze, to re-examine, to occupy itself of the final result ", Role "analyzer, manufacturer, finisher ", Suggestion "one would have, I occupy myself, etc ", problem "rotor of the wind mill", Participants (CS, VB, T.M), Resources "existing, average materials, generator ".

The phase of positioning, in our example, bonds between the identified concepts seem: argument/suggestion, try/problem, taking part/competences/role.

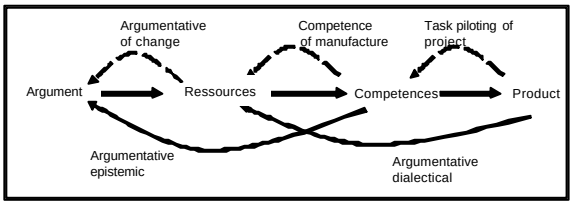

Figure 5: The aggregation strategy based on the carry out task

While analyzing, bonds between the sociological points of view, psycho-cognitive and co-operative work, we defined aggregation strategies on these bonds.

A first type of bonds appears between the concepts argument, resources, competences and product. It makes it possible to propose the realization of the tasks and the evolution of the design. These bonds request criteria like argumentative of change, dialectical and epistemic like competences of manufacture and task of project piloting.

One can notice that a first unification is made with criteria, this first unification is shown by dotted lines on

(Fig 5). We explain thereafter the exploitation of this aggregation strategy on the example of design of a wind mill:

• the result of a first iteration of this strategy showed us that:

• Argumentative of change (Argument /Resource): Statement 3 "C.S: Considering its motivation and materials at its disposal ", one notices an evolution of the argumentation based on the resources. In the same way, an evolution of attitude was indicated with the interactions which followed the first proposal.

• Competences of Manufacture (Resources /Competence): Statement 3: "C.S: Manufacture of the rotor V.B should occupy itself some considering its motivation and its materials "a competence of manufacture bound the competence of work required with the resources necessary and possible to carry out this work.

• Task of piloting (competences/product): Statement 3: "C.S: I join my opinion to that of T.M, and I propose…," of another with dimensions if that requires a new manufacture of the rotor, VB should be occupied some considering its motivation and its materials "the criterion of task of piloting binds in this example competence to the final result, that of obtaining the product (the rotor of the wind mill).

• A second iteration of aggregation made it possible to identify:

• Argumentative epistemic (argument / competences): Statement 1: "V.B: One should analyze and re-examine the balancing of the rotor our selves." The notion of new revealed competences pushed the vision of the participants to change position. This new data pushed the participants to advance other types of arguments in relation to new revealed competences.

• Argumentative dialectical (Resources / Product): Statement 2: "T.M: .. for the final result of the rotor...the generator to be used", the dialectical one here, offer the possibility of an answer to allow the introduction of a new data which is the choice of material to use "the generator" for the wind mill.

A second aggregation strategy related to the negotiation can be identified considering the dialectical exchanges and based on the negotiation which is for a number of researcher an interaction where the speakers seek to conclude an agreement starting from an initial situation where such an agreement misses (if there is a conflict or not). This definition is closer to that adopted in linguistics studies (Moeschler, 1989; Kerbrat-Orecchioni, 2005; Clark & Schaefer, 1989; Roulet, 1992). The aggregation strategy based on the negotiation can emerge starting from the relation between participant, role, suggestion and argument. Adding to, dialectical criteria argumentative, we distinguished the criteria from questioner and verificator defining participating in a negotiation. In the same way, role criteria (to take, to offer and change...) can reveal bonds of negotiation. In addition the argumentative criterion of change must be considered to illustrate the changes advanced in a negotiation (Fig 6).

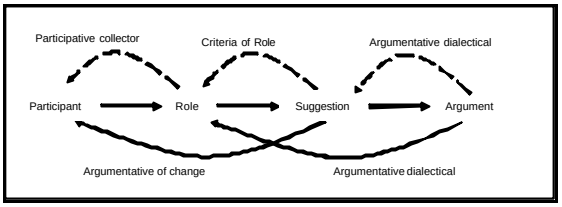

Figure 6: The aggregation strategy based on the negotiation

For example:

• Taking part questioner (taking part/role): Statement3: "C.S: I join my opinion to that of T.M ", It is noticed that one of the actor emitted a suggestion of agreement leading towards a possible alliance. It consolidated the catch of a role of one of his colleagues (related to physical competence and mechanical cf. 4.2). The questioner here gave an opinion after intervening evolution of knowledge in the interactions.

• Criterion-role (role/suggestion): Statement 3: "C.S: I propose that it is occupied....should occupy itself some considering its. », one uses the criterion of role to support and validate the suggestions and the proposals on the role to be taken with the execution of a precise task.

• Argumentative dialectical (role/argument): Statement 2: "T.M: for reasons of times. "The dialectical one here offers a direct attack like answer, allowing the identification of the problem of the lack of time, "it is necessary to call upon a firm of consulting".

From a knowledge management point of view, one will say that the relations indirectly to create between (Argument Role) and (Suggestion Participant) allow a tacit reading of the meeting. Conceptually we will say that the classification criteria build interdependent relations between the concepts.

We noticed also a strong bond connecting task suggestion and role, this concerns organization thanks to the two criteria (Fig 7):

- Criterion of specification: a task criterion which is related to much more the phases of the project management, and attributions, assignments.
- Criterion of role: (assignment, to offer) strong and direct functionality allowing to assign a role with a task.

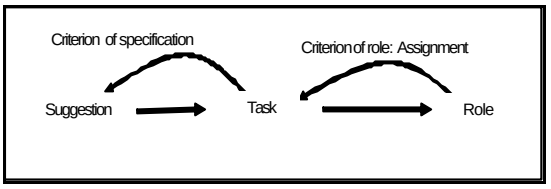

Figure 7: The aggregation strategy based on organization of project

For instance:

- Criterion of specification (suggestion / try):Statement1: "V.B: to re-examine. », to re-examine some tasks which have be missing with the project of wind mill.
- Criterion of role (task/role): Statement3: "C.S I propose that it is occupied..." should occupy itself some considering its. », assignment of a role to a task.

In this paper, we show our first studies and outlines of definition of aggregation strategies for the cooperative problem solving on design projects. We illustrated examples drawn from real project of design. We will try thereafter to build other strategies based on sociological theories, psycho-cognitive and organisational and we aim at validating these strategies on a whole design application. The result of this aggregation allows having a conceptual structure of the projects knowledge. We plan to define this structure for a project memory.

5.0 CONCLUSION

The traceability of project knowledge is only one first stage for the representation of the cooperative problem solving. Indeed, tracks including concepts like participants, suggestions, competences, constraints, tasks, arguments, decisions are only representation of situations of cooperative problem solving. Aggregation using classifications of this information must be carried out in order to emphasize deep knowledge and to show the strategies of negotiation used to deal with environments. We use representation level recommended in knowledge engineering which proposes to make explicit the "why", "how" and the "what" of knowledge. We study the projection of this representation to express a knowledge emerging from of a collective activity like design projects.

We presented in this paper our work on the definition of a method of aggregation based on a hierarchical classification. Therefore, we developed the different phases of this aggregation which is based on criteria and strategies. The criteria and the strategies were identified after a study of the project knowledge under three points of view: sociological, psycho-cognitive and cooperative work. This study made it possible to propose the main concepts and relations between these concepts to be considered a project memory. We plan to look further into this study and to determine other aggregation strategies.

We illustrate strategies on an example extracted from a project track of design of a wind mill. We plan to validate the process of classification we defined, on the whole of these tracks and on other project tracks, for instance design of vehicle prototypes.

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