QUORUM-W

A Group Decision Support Tool for the Internet Environment

Renata Mendes de Araujo
COPPE/UFRJ, Programa de Engenharia de Sistemas
Caixa Postal 68501 - 21945-970, Rio de Janeiro, RJ, Brasil
e-mail: renata@cos.ufrj.br
http://cos.ufrj.br/~renata/mypage.html

Hugo Fuks
Departamento de Informática
PUC-Rio
R. M. S. Vicente 225 - 22453-900, Rio de Janeiro, RJ, Brasil
e-mail: hugo@inf.puc-rio.br
http://www.inf.puc-rio.br/~hugo/

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Abstract: This article talks about the building of QUORUM-W and the strategies outlined to accomplish this work. QUORUM-W is part of a research project called—COLMEIA—which focusses on the study of the issues concerned in the construction of an environment for the development of custom-tailored cooperative applications.

Keywords: CSCW, groupware, Internet, WWW, group decision support systems

Resumo: Este artigo apresenta os objetivos esperados com a implementação do ambiente QUORUM_W e as estratégias levantadas para realizar sua construção. QUORUM_W é parte de um projeto de pesquisa denominado—COLMEIA—que visa o estudo de questões relativas à construção de um ambiente para o desenvolvimento de aplicações cooperativas configuráveis.

Palavras-chave: Trabalho cooperativo auxiliado por computador, Internet, WWW, sistemas de suporte à decisão.

1. Introduction

The development of groupware is still an unanswered issue, because there are no successful groupware tools supporting the interaction of groups performing complex tasks. We may justify this in research by considering the way that this research has been conducted till now. Groupware tools are usually developed having the goal of supporting very specific group tasks and modes of interactions. Considering that group dynamics are almost unpredictable, it is hard to support them with tools that use prescribed styles of interaction.

COLMEIA [CAMP95] is a research project being conducted at the Federal University of Rio de Janeiro which focuses on the study of issues concerned in the construction of an environment for the development of flexible and custom-tailored cooperative applications. This research effort is centered on the range of possibilities offered by the WWW-Internet environment.

QUORUM is a decision support tool for software development groups that is part of the COLMEIA effort. A prototype of QUORUM was developed using Lotus Notes [LOTU93]. According to COLMEIA objectives, we chose the WWW as a platform for implementing a new prototype of QUORUM, designated as QUORUM-W (QUORUM through WWW).

The main objective of this article is to explain the goals expected with QUORUM-W construction and the strategies outlined to accomplish this work.

The article is structured as follows. In section 2, we present and describe the COLMEIA project by enumerating its main objectives and research strategies. Next, we describe QUORUM, one of the tools that will define technical requirements for the environment to be developed in COLMEIA. We present its objectives, basic characteristics and needs for future development. In section 4, QUORUM-W is presented. Its research goals and strategies are outlined and its specification is described. At the end, we show some final considerations.

2. Project COLMEIA

As we mentioned earlier, the development of groupware is an important research issue as we can not see a mature cooperative tool in large use yet. In general, research is focused on the development of highly specific tools to support a certain task within a specific context. According to COLMEIA researchers, there is a growing need for looking at the general aspects of computer supported cooperation.

The Internet—the computer infoway that is changing the way of information sharing among people throughout the whole world—is becoming more powerful with the resources made available by the well-known World-Wide-Web (WWW).

Considering all the advantages offered by the hypertext metaphor when applied to cooperative applications [STRE91] and considering the extent through which the Internet is gaining acceptance and use, we can reasonably see the WWW as a promising environment for developing groupware tools and for studying the various aspects related to cooperative work.

Consequently, the objective of COLMEIA is to build a framework for developing cooperative work tools that could be customized and integrated according to the developer's needs.

We believe that, using this framework, we have an environment where the study and exploration of groupware tools can be done in a faster way, because of the flexibility of this environment in providing a large range of cooperative resources.

This environment, called INTERCONNECT will be built within the Internet environment and is described in the following section.

2.1. INTERCONNECT Architecture

The INTERCONNECT architecture has three basic layers: the application layer, the service layer and the support layer. These layers are disposed as shown in fig. 1.

The *application layer* is mainly the user interface, where users may customize the services provided by the service layer to build their cooperative applications.

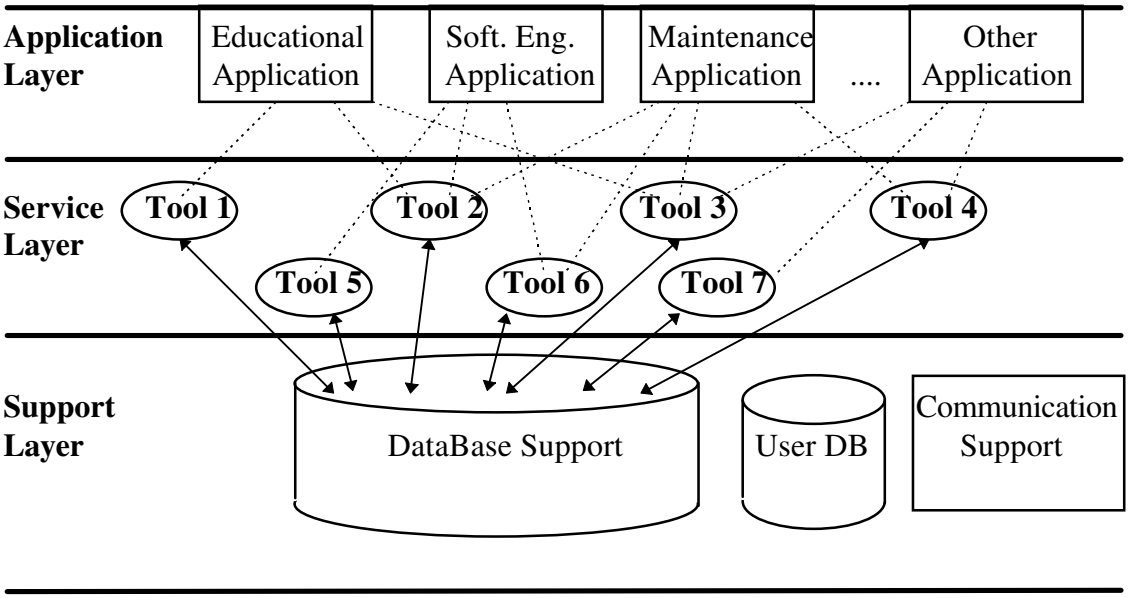

Figure 1- INTERCONNECT architecture

The *service layer* encloses the basic facilities required for cooperative work, namely: electronic mail, whiteboards, argumentation tools, cooperative editors, knowledge bases and so on.

These services will use a common set of informations and operations for supporting their use and integration. This set will be provided by the *support layer*. This layer embodies the database and communication facilities.

The project centralizes its efforts on building the application and support layer, once the service layer will be constructed by gathering some tools already available on Internet.

To establish the services that INTERCONNECT should provide at the service layer, a survey about the common services needed by cooperative tools was conducted. Initially, these services will be based on specific features identified on cooperative applications developed by the research group. These applications are: a tool for cooperative learning support (ARCOO) [BARR94], a toll for cooperative software maintenance documentation (ARCoPAS) [CAVA94] and a decision support tool for software development groups (QUORUM)[ARAU94a] [ARAU94b].

3. QUORUM - A Decision Support Tool for Software Development Groups

Software construction is a highly cooperative process. The number of people involved in a development project is proportional to the complexity of the software being built. At each process step, it is necessary to establish the communication and interaction among users, managers, system analysts and programmers through a continuous information flow exchange. Furthermore, the system development is becoming a multidisciplinary task, involving the participation of people from areas outside computer science.

This cooperative feature has guided researchers in software development to provide solutions for decreasing communication, interaction and task coordination hurdles faced by software development groups. Consequently, what we see today is a tendency for the emergence of cooperative software development environments that are able to support group interaction along the software development process.

Among the tools these environments may provide, the decision support tools deserve especial attention due to the importance of decision making in the development process. Given that decisions taken by the group influence the product being developed, they must be taken in a productive way and must ensure quality.

3.1. Decision Making in the Software Development Context

Decision making is a complex activity. To enumerate the possible solutions for a problem, to analyze them in details and finally, to choose the solution which best fits the decision problem, is a task that often demands the use of a variety of methods and other resources. However, the decision making process is not just choosing the best solution for a problem and its application. It is also important to record the steps, conversations and reasons that led to a conclusion and why, for example, one alternative was accepted whereas another was rejected.

This record is notably required during the software development process [LUCE91] [POTT88] [YAKE90] if we consider that this process involves constant need for decision making and that these decisions have an impact on the product being developed, especially in the maintenance phase.

The absence of information about decision justifications and their results damages the development process and the future system maintenance. We often face the following questions while working on development: “Why was it done in this way?”, “Who decided

that?", "On what basis did we create that?"; "What did we have before changing this?".

These questions, when not correctly answered cause:

- delays, because the group has to remember the decisions taken before;
- doubts, because the justifications may not be sufficiently clarified.

This scenario could become more amenable if decisions were recorded during the process. The more detailed the decision history is, the greater the amount of information which can be examined.

3.2. QUORUM Specification

QUORUM is a decision support tool for software development groups. QUORUM aims to improve productivity and quality of the decisions made during system development, facilitating the developers' communication and integration. QUORUM also enables decision record and reuse of both decision process and results. This decision support tool takes into account the peculiarities of the decision making process in software development.

The tool supports group discussion and argumentation, providing resources for structuring the decision problem to be solved and providing a method for helping group members in reaching a final decision. Furthermore, it records the information generated at each phase of the process.

3.2.1. Decision Method

QUORUM provides a method for structuring a decision and dealing with the complexity of the decision making process. Decision problems are organized by a structure that represents the interaction and interdependency of the parts of the decision problem. The decision process structure also defines a discipline, or better, a sequence of steps for solving the problem and helps to determine the best solution for the problem. The decision method provided by QUORUM is the Analytic Hierarchic Process (AHP) [DYER92].

The AHP is based on constructing a hierarchy of criteria for evaluating the alternatives of a problem. Having established this hierarchy, the evaluators can judge which alternative better fits each of the criteria and, based on each evaluator's judgment, the method is able to conclude which alternative is the best one.

We may structure the hierarchy levels through various elements, as shown by the example in figure 2. The goal of decision sits at the top of the hierarchy. The levels that follow contain other elements that contribute for the quality of the decision. The elements' details grow while we go down the hierarchy. The bottom level contains the solution alternatives or choice options for the problem.

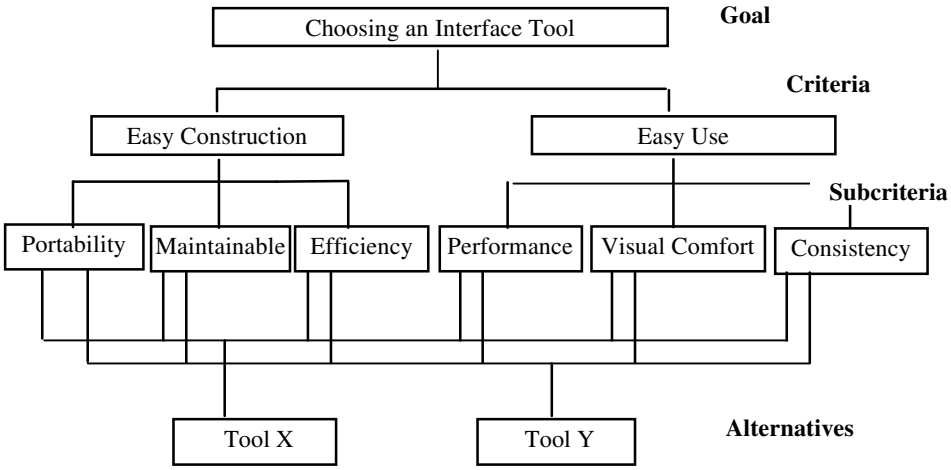

Figure 2 - Hierarchical representation of a decision problem

After the problem has been structured, the method's next step is to evaluate the alternative's priorities, regarding each criterion and the evaluation of each criterion's importance regarding the overall goal. The approach to obtain each element's priority is through comparisons among them. The tool is responsible for concentrating each comparison and, after some calculations with these values, the tool determines the best alternative.

3.2.2. Coordination Support

Within QUORUM, group activities are controlled by defining roles and responsibilities for the participants and by splitting the decision making process into specific phases. The assignment of roles helps coordination due to the association of each role to a specific set of responsibilities and activities. The definition of process phases helps group members in finding themselves inside the process, being notified of those steps already finished, those being conducted and those yet to be taken.

The first phase of the decision making process is the problem definition. This step involves a clear definition of the problem to be solved and of the goals that the group aims to reach, i.e. to describe the decision problem in detail and to subdivide it into other subproblems, trying to restructure the decision goals.

Next, the group enters the argumentation phase, in which members present their contributions for solving the problem and exchange opinions. The objective of this phase is to determine possible alternatives for solving the problem and to enumerate the criteria for evaluating them.

The last phase, called the decision phase, consists of using the AHP to determine the best alternative based on the group judgment.

3.2.3. Group Communication

QUORUM is a remote and asynchronous tool. Group members establish communication through an information base, built using the hypertext metaphor. The hypertext helps group decision making by linking information in a flexible way, granting liberty for expressing ideas and contributions in a natural and logical way, supporting that way the record of informal and ill-structured information [STRE91].

Given that the elements being manipulated throughout the discussions are group member's ideas and thoughts, and that it is necessary to rearrange these ideas in a structured and organized product, the hypertext metaphor emerges as an engine to link these contributions, establishing representations for the objects being manipulated and, consequently, clarifying the discussion.

Therefore, the hypertext web serves as a communication medium among members, allowing each member's contribution to be viewed and challenged by other members. It establishes a semi-formal communication medium, i.e. the hypertext provides a natural communication channel between members meanwhile structuring and organizing their discussion.

QUORUM provides specific elements for each kind of contribution to be included in the discussion, establishing an argumentation model. This model is fundamentally based on the IBIS model [RITTEL]. These contributions are denominated *discussion elements* and may contain suggestions for alternatives, arguments that support or rebut other elements, and facts to justify opinions, questions and positions.

During the discussion, group members may also establish communication using a mail tool. This medium is especially useful to: ask more information to members, make general comments about the discussion, ask for more participation, communicate details or changes, send information and so on.

3.2.4. Information Sharing

The information base supported by the hypertext and produced at each discussion is used as the group memory. Through the association web, the contributions are recorded as well as the discussion dynamics. The record of decision is warranted, enabling group members to examine the base when needed, searching for information that may clarify the reasons for previous decisions.

This decision record also enables other groups to reuse the information contained inside the information base. The discussion structure, the alternatives suggested, the hierarchy of evaluation criteria and other information may be reused by other groups facing similar problems.

3.2.5. Prototype

A prototype of QUORUM was developed using Lotus Notes [LOTU93] due to the need to prove the viability of its specification and for experimentation purposes. Although we may not testify its use in a large extent yet, Lotus Notes proved to be an suitable environment for developing simple cooperative applications. We say simple applications because although it provides some cooperative requirements such as electronic mail, distributed data bases and a type of hypertext resource, the applications may not use more complex resources for supporting more intricate tasks requiring greater levels of interaction among group members.

3.2.6. The Future of QUORUM

One of QUORUM's future plans is to extend its information model in a way that it will be able to record not only decisions taken and how they were made but also the artifact versions that were influenced by these decisions. Recording the decision consequences, that is, if the chosen solution achieved or not, the perspectives initially outlined, what were the problems due to that decision and the real costs of the solution implementation, are also interesting possibilities of evolution.

Decision reuse is another point which also deserves attention. The enlargement of this process by more elaborated query engines and the establishment of evaluation criteria libraries is a relevant question concerning this issue. It is also possible to improve the possibility of reusing the decision experiences and, to accomplish this, we need to analyse better ways for capturing group contribution, enlarging the information base.

Another extension is to integrate many information bases into software development decision communities, that is shared information bases about software development decisions handled by a QUORUM like tool, offering navigation, query and reuse engines operating over the information base.

Porting QUORUM to other platforms is also a future extension, for QUORUM needs more flexibility and more resources to achieve better reuse, artifact version control and its rationale.

4. QUORUM-W: QUORUM through World Wide Web

QUORUM-W was conceived to accomplish COLMEIA's goals and perspectives for the development of groupware in the Internet environment.

As mentioned before, our overall goal with QUORUM-W is to implement QUORUM in another platform, following its evolution points. However, we hereby outline other specific objectives we have in mind to be accomplished within this work:

- To study the implementation of tools in Internet within WWW and to gather experiences to contribute to COLMEIA's future development of INTERCONNECT.
- To evaluate some Internet tools that may support QUORUM-W in its work for further

integration in INTERCONNECT.

- To conduct real experiments to evaluate QUORUM's requirements and new possibilities.

We defined an initial plan of work to conduct this research:

First, we should review QUORUM specification to enable a faster implementation as we wish to obtain concrete results with its WWW implementation.

Next, we should evaluate the resources made available by the WWW to implement the tool and study its use. An application that is under evaluation now is WIT (Web Interactive Talk). WIT is a form-based argumentation system to support discussions about WIT technical matters and to store these discussions in a more structured fashion [WIT94]. We have not evaluated it sufficiently to present our final conclusions but, on first impressions, it is very good but we intend to go further.

We also need to study WWW instruments, such as: composing HTML, especially form supporting, submission of forms through the web and above all, we must analyze the possibilities for storing contributions (by simply managing html pages or through a database system). In parallel with this study, we will begin QUORUM-W implementation. With a new prototype we intend to conduct real case studies of its use.

QUORUM_W main objectives are:

- To aid the group in structuring the decision problem.
- To aid the group in the definition of the decision task objectives, avoiding unnecessary discussions.
- To support group communication during the decision process.
- To aid the group in outlining solutions alternative and criteria for evaluation.
- To support the group in choosing the best solution by voting.
- To support the record of contributions generated during the discussion process.
- To allow "navigation" throughout the discussion base, which is the group memory.

4.1. QUORUM-W Specification

As our main objective is to analyze the implementation of QUORUM in the Internet and to use it in real situations, we simplified its specification to construct QUORUM-W in a faster way without compromising the study results. This simplified specification is described in the sections that follow.

4.1.1. Decision Method

We decided not to use AHP in QUORUM-W due to its implementation complexity. We decided to study the use of AHP in other research efforts, instead of QUORUM-W, due to

our need to focus on application development in Internet and its use. In fact, we preserved the idea of criteria evaluation of alternatives.

We have simplified the method in the following manner: the alternatives are enumerated by the group and some criteria for alternative selection are also outlined (it is not required to be in a hierarchic form). Each group member evaluates the alternatives according to each criterion and the overall judgments are combined to obtain the alternative preferred by the group.

4.1.2. Coordination Support

To interact through QUORUM-W, the group must be divided into *experts* and *coordinators* for those are the roles supported by QUORUM-W. The experts are those members who are responsible for taking decisions or are experts on the problem being discussed. They make contributions, take part in argumentation and generate ideas. The coordinator organizes and conducts the process, administrates the information base and is responsible for reaching conclusions before the deadline.

The decision making process is divided into two steps: *discussion* and *decision*. The discussion phase embodies the tasks of problem definition and information exchange (argumentation). The main objective of this phase is to enumerate alternative solutions generated by the group and to define some characteristics by which they will be evaluated. The decision phase embodies each individual's analysis of alternatives and the best choice. The results of these phases are detailed on table 1.

Discussion Phase	
1. Problem Definition	Clarification of goals and specification of the problem being solved
2. Argumentation	Information exchange and argumentation on the proposed alternatives
3. Alternatives Enumeration	Outline of alternatives suggested and possible criteria for evaluating them
Decision Phase	
1. Analysis and Judgment	Evaluation of alternatives by each member. It is a simple analysis, where each one presents the evaluation of each alternative according to each criterion.
2. Conclusion	Integration of judgments and choice of the best alternative according to the group's judgment.

Table 1 -Decision making phases in QUORUM-W

4.1.3. Group Communication

QUORUM-W is also a remote and asynchronous tool where group members establish their communication including their contributions in the information base supported by the application. This information base will be implemented using the hypertext resources available in the WWW, where each contribution will appear as a form-based HTML page (hypertext node), linked to other contributions related to it.

QUORUM-W will also use a mail system to establish parallel communications during the discussion. This requirement is also easily implemented by Internet electronic mail support.

4.1.4. Data Model

A simplified scheme of the QUORUM-W data model is outlined in figure 3. This model shows the information which will be recorded on the information base for each discussion performed by the group. As part of QUORUM specification, these entities may be queried and even reused in other discussions.

4.2. QUORUM_W Architecture

QUORUM_W implementation follows the architecture described in figure 4, which is based on Coad&Yourdon's layered architecture for object-oriented software development [COAD91]. This layered architecture defines the Coad&Yourdon's strategy for organizing and coping with software design. Basically, the strategy divides the design task into the definition of four components, each one dealing with a specific aspect of software design, namely: Problem Domain, Human Interaction, Task Management and Data Management.

The Problem Domain Component (PDC) comprises classes and objects that models the information entities for designing the software. Within QUORUM_W design, this component embodies the classes and objects identified by the data model described above.

The Human Interaction Component describes the user interaction process using classes and objects that models the human interaction design. QUORUM_W use WWW as its human-interface therefore, this component describes the HTML pages that present the contributions stored in the discussion base. This component also describes the HTML forms provided for taking part in meetings.

The Task Management Component (TMC) focuses on modeling the classes responsible for managing the system's tasks. This component receives and treats requests originated at the user interface. These classes are basically CGI (Common Gateway Interface) programs, necessary for dealing with HTML forms.

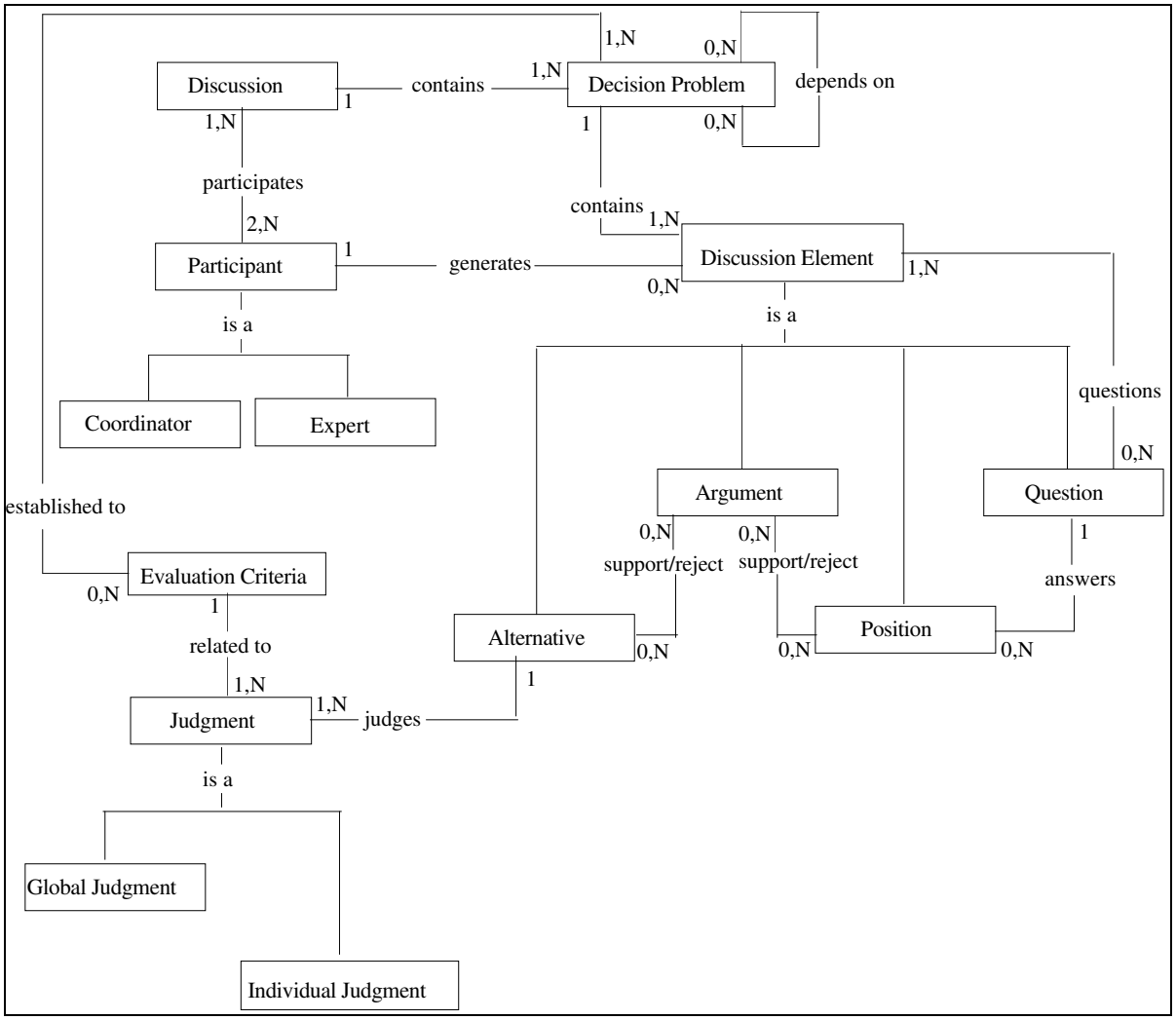

Figure 3 - QUORUM-W data model

The Data Management Component (DMC) provides infrastructure for storage and retrieval of objects from a data management system. Its main purpose is to isolate the solution adopted for object persistence (object-oriented database, relational data base or flat files) from the problem domain component. The first version of QUORUM_W object storage engine will be based on the management of flat files. The following version will use INTERCONNECT'S relational database solution.

4.3. Final Considerations

QUORUM-W differs from the first QUORUM prototype on the following points:

- QUORUM-W's purpose encloses a greater range of contexts, not only software development decisions.
- The communication support mechanisms were not altered but certainly improved by the new WWW resources that supply them.

- The assignment of roles among group members was simplified.
- The decision phases are almost identical, differing only on the method used to structure the decision.
- The data model was also simplified, because of the absence of the AHP method.
- The use of a relational database to make up for Lotus Notes database engine.

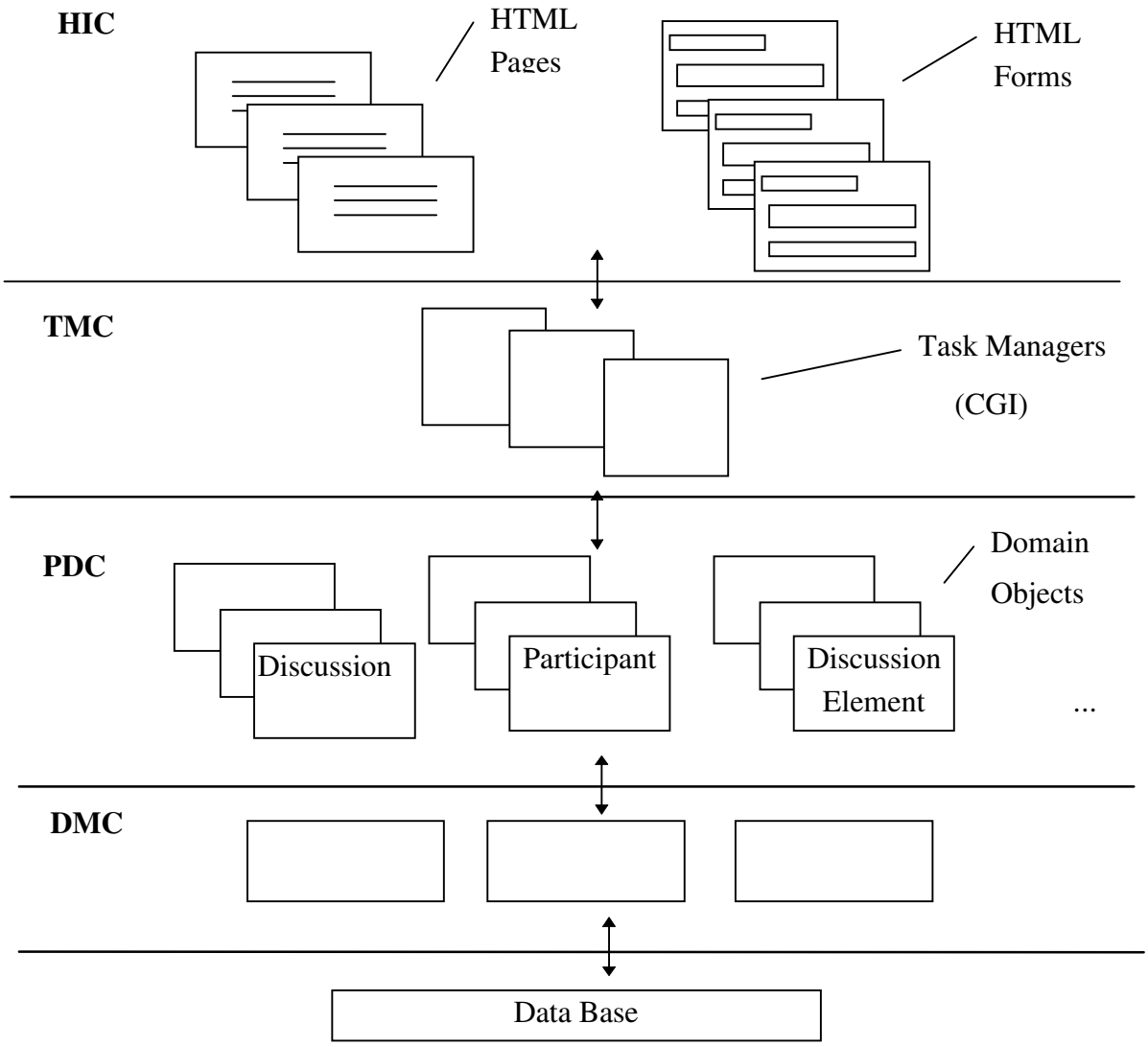

Figure 4 - QUORUM_W Architecture

5. Conclusions

In this article, we initially presented project COLMEIA whose main objective is to study the issues concerning groupware implementation. The project's main belief is that it is possible to build an environment suitable for groupware development. This environment, called INTERCONNECT, lets developers to choose from a set of cooperative resources, those which they want to integrate into their cooperative application. To implement INTERCONNECT, COLMEIA's researchers first focused on the power offered by the

WWW in integrating Internet resources.

To list INTERCONNECT requirements, three cooperative applications were analyzed to look for common features that could later be generalized for other cooperative applications. One of these applications is QUORUM, a decision support tool for software development groups. We presented QUORUM objectives, specification and evolution issues.

QUORUM's next development step is to implement it in a more flexible environment. This new tool - QUORUM-W - will provide resources for better analyzing its use. Using QUORUM-W, we expect to study the issues that concern the building of applications in the Internet that will contribute to achieve COLMEIA research goals and to conduct case studies with the use of QUORUM-W in real situations.

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