Improving the Organisational Memory by Recording Decision Making, Rationale and Team Configuration

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We present the architecture of an Organisational Memory including the representation of workflow, participant profiles and the rationale of the decision making process. The added value of the proposed architecture resides in the availability of the recorded experiences and know-how at the individual and team levels for future reuse in planning, decision-making and business process optimisation. One of its distinctive features is the consideration and explicit representation of the information related to decision-making as a major component of the recorded experiences. The representation of the workflow as well as of the decision making is dynamic, reflecting the evolution of the work process. The suitability of these parts of the architecture is illustrated by an organisational memory deployed at the IMP.

1. Introduction

1.1 Organizational Memory

A growing interest within competitive organisations is the management of the knowledge and expertise of its members, thus the increasing research efforts to devise new forms of access, maintenance, promotion and reuse of the organisation intellectual resources. One of the major challenges of an Organisational Memory is the provision of an agile and relevant application of the memory records for the intended purposes. Another major goal is the facilitation of continuous learning within the organisation.

An Organisational Memory can be understood as a repository of valuable knowledge generated by an organisation through its continuous activity [Alvarado et al., 2004; Dignum V., 2004]. This knowledge can be analysed, structured and distributed with the final aim of reusing it as a support to managerial decision making, which spans activities as diverse as enterprise strategic planning and the configuration of teams responsible for the execution of a project.

This functionality is rooted in the preservation of the individual and collective experiences and know-how, which are in play during the task execution process. However, if an Organisational Memory is to achieve its full potential, its records should be easy to create, navigate and retrieve. In turn, both kinds of aspects, recording and use, require an open organisation and an efficient classification of information at the backend of the organisational memory system.

The basic components of a typical Organisational Memory are

- A set of documents acting as the building blocks in the representation of information generation and exchange.
- A set of scheduled tasks or activities, i.e. the workflow.
- The structure of the organisation composed of individual members working within groups (that are dynamic); it is worth noting that the usual level of description for the members is at the level of static *yellow pages* of professional profiles.

1.2 Information Classification

The first step in the operation of an Organisational Memory is the organisation of the available information through a classification of documents (as the building blocks of information generation and exchange). As a result, the information is grouped into categories, which in turn, will facilitate its future retrieval and further application in the intended context.

The accurate classification of diverse and complex information is achieved through the use of taxonomies and ontologies, their proper specification providing the required precision in the future application of the information. The classification should be flexible enough such that categories could evolve through the creation of new classes by generalisation or specialisation of the existing ones, also allowing the addition of new information and the management of incomplete, uncertain and ambiguous information.

In this paper we are not directly concerned with the information classification problem, in part because there are tools that solve the task such as Verity [Verity, 2004] and Autonomy [Autonomy, 2004].

1.3 Workflow and Work Team

The workflow of a project consists of a set of tasks or activities each having input and output information. Activities are organised according to precedence relationships, either sequential or co-ordinated in a concurrent fashion. The workflow tasks are assigned to the members of the organisation, either individually or in a team.

It is well known that the success of a project strongly depends on the interpersonal relationships and the emotional integration of the team members, especially when the teams are working under severe conditions or participate in critical missions. However, the team configuration for a project is usually decided by the project leader according to experiences from earlier projects or based on recommendations from colleagues. There is seldom a methodological or technological support for these decisions and they rarely take into account all the relevant information about the psychological, social or emotional profiles of the people involved.

Two major challenges in the improvement of the organisation performance are the provision of appropriate representations for the technical systems and for the people management and assessment systems, and their flexible integration. We adopt the holistic approach proposed in [Martínez-Miranda et al. 2004], which presents a simulation tool that integrates the cognitive, psychological, emotional and social profiles and abilities of the team members for the configuration of teams in an industrial context.

The present work further extends the synergy of technical and people assessment systems, for individuals and for teams, as well as with the project workflow. The integration of these elements is achieved within the framework of an Organisational Memory system.

1.4 Decision Making and its Rationale

A decision can be viewed as the selection of one solution for a problem from among a set of competing alternative solutions that solve that problem. Such a selection is made on the basis of a comparison of all the solutions being considered with respect to one or more criteria aiming to maximise the overall utility. When a complex problem is tackled, it can be partitioned into smaller sub-problems organised in an AND/OR tree structure, each sub-problem solved through a decision. In this case the overall solution to a complex problem can be interpreted as the set of partial solutions corresponding to the sub-problems within a branch of the tree. The decision rationale literature often refers to a problem as an "issue" and each of the competing alternative solutions for an issue is known as an “option” or a “position” [Lee&Lai 1991].

The expert's know-how is tightly related to the decision rationale obtained while undergoing the experience of solving a problem. It can be argued that being able to explain and argument the reasons for action in front of a problem is an essential part of constructing an experience. Furthermore, by recording the reasons for not selecting other solutions a system can prevent future mistakes. Lastly, in the face of project changes the rationale of the decisions can be very helpful in constructing a fresh solution. These points convey the frame and facilities to record an aspect of the know-how of the experts that are involved in a valuable experience. We believe that this is one of the main contributions of the paper.

Therefore a worker may use his/her previous knowledge, consult the organisation best practices and search in external information sources to perform an assigned task. It is in this fashion that the Organisational Memory associated to the know-how of the personnel grows from the experience acquired during the development of a task and the feedback that is received.

1.5 Proposal

We are specifically proposing to augment the information model of the Organisational Memory to account for the integration of:

- Workflow, considering the activities, the people performing such activities and the timetable.
- Information about the members of the organisation including their psychological, emotional, social and cognitive profiles, and their performance in previous projects.
- Decision making, related to every issue to be resolved.
- Decision rationale, i.e., the explanations, arguments and justification about decisions.

As a result of the maintenance of an Organisational Memory the following advantages can be expected:

- Improved application of past experiences and best practices within the current project through the use of decision rationale records.
- Facilitation of information search and retrieval.
- Improved communication between users and experts.

Section 2 is an overview of information modelling for engineering design. The rest of the paper presents an Organisational Memory architecture detailing some of its components: the workflow in section 3, the profiling of the members of an organisation in section 4, and the representation of decision making and rationale and the advantages of such representation in the following two sections. The last part of the document makes an analysis of our proposal and possible future trends.

2. Background to information modelling of Organisational Memory

2.1 Information Models for Process Design

Several information models have been proposed in the literature, such as MODEL.LA [Stephanopoulos et al. 1990a; Stephanopoulos et al. 1990b], nDim [Westerberg et al. 1997] and KBDS [Banares-Alcantara 1995; Banares-Alcantara&Lababidi 1995]. However, we will base our analysis on the Conceptual Lifecycle Process (CLiP) information model for chemical engineering processes presented in [Bayer&Marquardt 2004], being the most recent, it has adopted many of the useful ideas from earlier models and has resolved some of their limitations. In this model a process is divided into activities organised by the workflow. Documents act as carriers of data, which encodes information. Thus, a document (or a set of documents) contains

the input information for an activity. This data input is transformed by the activity and a document (or set of documents), containing the information output, is generated.

The CliP information model is organised into three levels of system abstractions. The more general Meta Meta Class system has Meta Classes instances of different kinds of systems, e.g. Technical and Social systems that, in turn, have class instances of particular systems. Two examples of Technical Systems are the Mathematical Model and the Chemical Process System; the Management System is a kind of Social System. Based on this hierarchy of system classes CLiP deals with an integrated representation of workflow, processes, activities and assigned persons through documents.

The integration of the above systems, which encode information in diverse formats, is based on the definition and use knowledge representation techniques that recently have become formalised as ontologies. Mapping between different information representations from different sources allows the communication and information sharing between systems.

2.2 Computer Support Systems

Several systems have been proposed for the support of organisational memories, such as CoMMA [Rabarijaona et al. 2000] and FRODO [van Elst&Abecker 2002]. Perhaps the most relevant one for our purposes is the one described in [Tacla&Barthès 2003] for the automatic capture of operations performed on a computer and for the support in the organisation of "Lessons Learned" (or LL), which are clusters of operations and their associated documents, through the use of a multi agent system. We consider this work important on the account that, while considering knowledge as an item developed individually and maintained locally, the proposed system aims at the construction of a distributed group memory through the articulation of personal knowledge, stimulation of knowledge sharing and facilitation of a cooperative learning process.

A related work, [Tacla&Enembreck 2003], delves further on the formalisation of tasks as experiences based on the problem description (project data and persons involved) providing the context and solution (a description text and a list of resources used). The following operations are required for the formalisation of the experiences:

- Reuse of the information related to the captured task.
- Gradual formalisation of the information through a user-system dialog.
- Application of a multi-agent system to minimise the additional work required from a user.

However, as we will detail later, it is widely accepted that experiences are richer and more complex than what could be represented by clusters of operations and documents. A more complete representation of experiences based on the rationale of decisions is precisely one of the proposed contributions of our work.

3. Workflow and the assignment of people

3.1 Integration via the information model

We now approach the problem of integration of work processes through the input/output information to/from tasks; we assume that such input/output information is contained inside the documents exchanged across tasks. An information model that includes people (participants), workflow and documents is proposed, thus there is a need to consider the interactions between the

- workflow model (including timetables)

- input/output data-flow model, and
- participant's profile model, together with the assignment of the tasks in the workflow to the participants.

Every task in the work process requires input information and, in turn, generates an additional amount of information.

The incorporation of the documents within the overall work process by including all the information (data) describing the structural, functional and/or behavioural aspects of the tasks makes up a central issue in the integrated modelling of the pre-requisites and results of the work process.

In addition, documents such as profiles and evaluations of performance of the participants should be formally included in the model. These documents contain information on the professional, psychological and emotional facets of a person, and they can be used to identify the best possible team configuration for each project task in the workflow. The assessment procedures as well as the configuration of the team can be supported by the methodology described in [Martinez-Miranda et al., 2004].

We argue that, by taking into account all of these elements, it is possible to achieve a more inclusive knowledge management process and only then implementation should be started, see Figure 3.1.

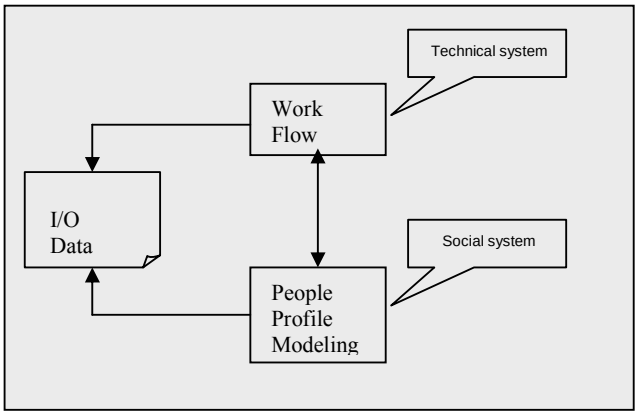

Figure 3.1. Modelling Workflow + Documents + Persons profile

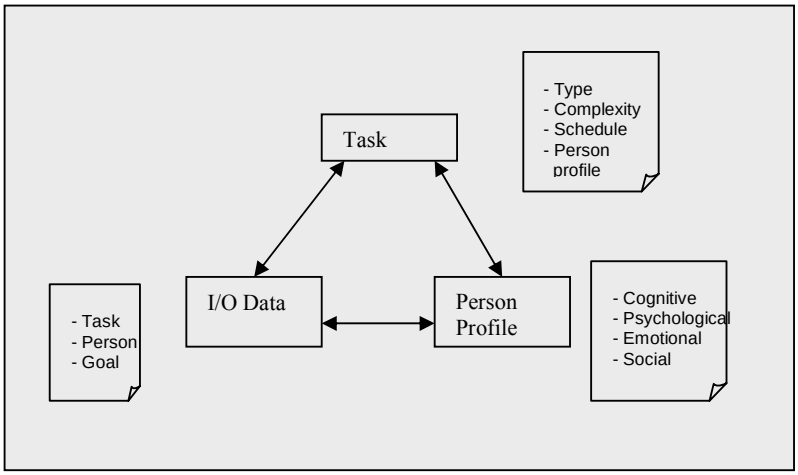

Figure 3.2. Task and person profile input data

There are diverse views regarding the relationship connecting workflow and data modelling, with some recommending their combination and others their separate treatment [Bayer&Marquardt 2004]. The drawback of the combination approaches is that the same documents must be included on different parts of the work process cycle. The approach supporting the separation of workflow and data models proposes the use of transparent links between each other. Despite the higher implementation costs of the latter approach, it can achieve a more balanced representation of the structural and behavioural aspects while maintaining self-contained and independent representations of both aspects of the overall model.

For the above reasons, we have adopted the separate workflow and data models approach. The models are linked by associating the input/output documents belonging to each task in the workflow.

3.2 Workflow and the people assignment systems

According to [Bayer et al, 2002] the frame for workflow modelling can be represented as a technical system, whereas the one that supports the management of the participants is a social system. For each task in the workflow the inclusion of the following data is appropriate:

- Preconditions
- Goal
- Type
- Complexity
- Schedule
- Participants' profile
- Deliverables

With the exception of deliverables, which are output information, the rest of the data should be included as part of the input information. The preconditions set the circumstances that make the task realisation feasible. The type characterizes the class of the task, whereas the complexity whether it is a simple or complex one; the latter case indicates an eventual decomposition into simpler tasks. The scheduling situates the task realization in the course of time and with respect to the rest of the tasks in the workflow. The participants profile describes the desirable characteristics of the people assigned to the task, and this is explained with some detail in the next section. The deliverables are the products resulting from the task realisation; they are the inputs for subsequent tasks in the workflow or the results for the final costumers.

3.3 People profile

Within an organisational memory the so called y*ellow pages* module is helpful for the project managers during the selection of the appropriate people for every project tasks. The aim of task assignment is to choose the right people for each task in order to complete the whole project in time and with the best possible quality. The current content of a typical yellow pages module would only include the members' *cognitive abilities* profile, i.e. information concerning scholarly training, technical knowledge and expertise, as well as a history of their participation in previous projects. This approach assumes that performance of a participant can be satisfactorily predicted from the knowledge and the training that were previously acquired.

However, it is widely acknowledged that the personality of individuals plays an important role in their performance. Similarly, it has been recognised that the collaboration within a team has a fundamental influence in the achievement of individual goals.

In this section the relevance of the participants psychological profiles in relation to the assigned tasks is stressed. The psychological profile includes personality type and social attitudes. Furthermore, emotions have recently been assessed as an important factor in the psychology of the people affecting their personality, in particular in relation to their work life [Goleman, 2000]. It is well known that the success or failure of any project (e.g. in industry) depends in part on the quality of communication and collaboration within the work team. In turn, communication and collaboration quality are affected by the empathy that the team members can create. As a result, work performance is frequently affected, either positively or negatively, by social factors.

Thus, the psychological profile is fundamental for the project management alongside the workflow to manage the non-cognitive characteristics that influence the worker performance. Accordingly, during the team configuration task it is convenient to estimate all the following facets of the people involved in the project:

- Cognitive
- Psychological
- Emotional
- Social

The more these aspects are considered and integrated, the better the probability of project success [Martinez-Miranda et al. 2004]. The information relative to the people profile must be stored within the yellow pages as part of an Organisational Memory to analyse and evaluate the performance of workers (and *vice versa*).

3.4 Dynamic workflow

The workflow of projects involving creative processes (e.g. design of artefacts) is dynamic, i.e. there cannot be a unique, predetermined and unchanged work plan but, under the particular conditions of each specific project, the workflow has, to a degree, to be evolved in time. It is important to realise that, in particular for this type of projects, the original timetable is seldom fulfilled: time consuming delays and/or unexpected tasks frequently crop up due to their very nature. As a consequence, the documents carrying the data within the project also evolve.

In the perspective of this dynamic process, the combination of supply chain concepts and techniques supporting the modelling of the work organisation, the ongoing process and the product has been studied within the vehicle and retail industries context [McKay&de Pennington 2001]. As a crucial matter in this dynamic, the synchronisation of

parallel/concurrent tasks is a huge challenge yet to be fully solved in current workflow models, in particular regarding the issues of computer system deployment and performance.

4. The personnel know-how

4.1 Work Experiences

Experiences are unrepeatable in their detail and highly dependent on the individual perception of each person. However, there are aspects of these experiences that provide the context to explain and highlight the importance of the worker experiences in an organisational perspective, e.g. the type of problem, the documents involved and the solution procedures. The challenge is to be able to identify the major features from the worker experience that could be relevant for future projects.

On the other hand, it has previously been recognised that documentation has a narrower scope than experiences [Shipman&McCall 1997] because it only contains immediate and direct explanations of the results rather than a more integral record of experiences. It is for this reason that a more encompassing pool of information is required. Decision rationale techniques are ideal candidates because they contemplate the maintenance of rejected alternatives, unsolved problems, dead-ends, arguments for and against each solution, criteria used in the evaluation of solutions, among others.

4.2 Issues and decisions

As mentioned before, a problem can be decomposed into partial sub-problems, each part being a nearly independent issue of the original problem (the problem itself being the main issue). A tree representation of linked issues (nodes) eases the analysis of the problem. Each tree node corresponds to an issue, and associated with each issue there are alternative solutions that could be tried. A decision involves the selection of which of the competing solutions will be implemented, the other solutions are rejected and are not further developed. Given that each branch can be interpreted as an alternative solution, the detailed solution to the overall problem is obtained by tracing all the issues in the chosen branch and retrieving their corresponding solutions. This representation corresponds to the widely used State Task Network (STN) [Barton&Pantelides 1994].

5. Decision making and rationale

Deciding how to record experiences (lesson learned) is a difficult and fundamental problem.
It has to be decided

- what to record out of all the deliberations, compromises, decisions and actions in which the members of the organisation are involved, and the associated partial results,
- in which way to record such a diverse set of elements,
- how to ensure that the resulting records are not only easily retrievable and in a format that allows its reconstruction by future users, but also amenable to be processed by a computer in order to achieve a degree of automation in an agile fashion.

As a solution we propose to represent decisions in the context of the workflow and the knowledge that is being shared between members of the organisation. On one hand the

execution of the tasks that constitute the workflow relies on decision-making processes. In that sense the availability of decision support methods and systems is a key component of the overall architecture. On the other hand, it can be argued that the record of the decisions and their components (e.g. the options considered and the criteria used for their evaluation), otherwise known as decision rationale, is perhaps the most convenient way to record best practices and lessons learned.

5.1 STN and decision rationale

A number of techniques have been proposed to record decision rationale, e.g. Toulmin's model [Tuolmin 1958] and IBIS [Rittel&Webber 1973]. One of the limitations to the application of any of these techniques derives from the goals with which they were originally developed, i.e. keeping track of an argumentation regarding social sciences issues such as law and diplomatic negotiations. Decisions in engineering are related to an artefact (or artefacts) being designed, constructed, operated or maintained, therefore there should be a link that exposes explicitly such decisions with the aspects or parts of the artefact to which they are related.

Systems such as QOC [McLean et al. 1991], KBDS [Banares-Alcantara&King 1997], n-DIM [Subrahmanian et al. 1993], DraMa [Brice et al. 1998] and CLiPS [Bayer&Marquardt 2004] have addressed this relationship and proposed different solutions for it. Regardless of the specific solution it is important to recognise that the relation must be part of the representation.

As mentioned in section 4.2, the proposed architecture solves this problem by combining the widely accepted STN representation and associating one or more issues to every transition in the network. Every issue has a number of possible solutions (options), and a decision involves the selection of one of these options. A decision is implemented throughout an action which is the embodiment of the transition between states. Thus decisions/actions are the transitions linking the issues/states.

One challenge for the recording of work experiences is to make their subsequent recovery agile, significant and relevant to the intended purpose. Only in this case workers confronted with similar tasks would be able to reuse the recorded experiences. As a result, the Organisational Memory will offer a mechanism to improve the workers performance and, consequently, the enterprise performance.

5.2 The granularity level: abstraction and particularity

The recording of decision rationale introduces additional problems such as devising procedures and systems for its capture and deciding on its granularity level. This last issue is important because an overly detailed level requires a large effort for recording and generates unmanageable amounts of information. On the other hand, no useful results would be achieved if the level is too abstract. Within these two extremes there are several levels of granularity with a trade-off in required effort and utility. Ideally, an Organisational Memory should allow for a flexible level of granularity, allowing its user to work at the desired level(s) of his/her choice.

5.3 Lessons Learned

The best practices and lesson learned are trajectories or paths in the decision tree. In the first case they are exemplars of tested problem solving methods that comply with organisational standard practices, and in the second any "interesting" procedure that is earmarked for future reference as an example of how to (or not to!) approach a problem.

The rationale for the adopted decisions contains the arguments and explanations that support them, while the rationale for not selecting the other available options contains the justifications

for their discard. Thanks to the structured fashion of the proposed representation and its amenability to being processed by algorithms, the recording of the lesson learned and best practices can be automated to an extent. Once the rationale has been recorded (in a manual, semi, or fully automated fashion) it can be used in the future solution of similar problems. This way, the private character of personal experiences is overcome and transformed into experiences at the level of the enterprise.

Lastly, the usefulness of the rationale associated to the discarded options could become useful in the future

- when circumstances under which decisions are taken have changed, e.g. increase in the price of raw materials, modifications to environmental laws, introduction of new technologies.
- to avoid repetition of mistakes, i.e. learning from past errors.
- to support modifications to the artefact, e.g. to increase its throughput to satisfy an increased demand.

6. Advantages of the proposed approach

A list of the advantages of implementing a corporate memory that includes decision rationale follows (some of them taken from [Dieng et al., 1999]):

- Reconciliation of multiple perspectives
- Re-negotiation of priorities in response to changes
- Identification of those decisions that are unaffected by changes (to keep them) and those that are affected (to review them)
- Communication of the rationale to others both in spatial (in a different location) and temporal (accessing the memory in the future) terms
- Recovery of insights, lessons learned and best practices to avoid "re-invention" and ensure standard procedures within the organisation
- Training new members of the organisation
- Analyse past and current forms of operation and simulate, test and/or discover new forms of operation.

It is important at this point to emphasise that the experiences being documented in the Organisational Memory should trace the solution to non-standard problems in the organisation. In such situations, the solution is not a routine one, but the combination of accumulated experience and/or *ad hoc* creativity necessary to rise to the challenge, e.g. critical circumstances such as recovering the control or stability in the operation of industrial devices. It is for those types of situations where the experience of senior experts is essential but not always available.

7. Discussion and future work

An organisation will improve its ability to solve problems to the extent that the experiences of its members and methods for problem solving can be codified, stored and made easily available to other members of the organisation. Furthermore, it is highly desirable to include the rationale for each decision, i.e. the arguments, justifications, assumptions and explanations associated with the selection of an option as the solution to an issue that is being solved.

On another level, and given that there is little methodological and no technological support for the selection of team members, we are planning to extend the team simulation system described earlier so that it also takes into account as inputs the past performance of every team member in

other projects, and the participation of external actors (the customers and users of the delivered product).

7.1 Case study: the development of an organisational memory

7.1.1 Workflow

The integration of the proposed approach within the design and the deployment of an organisational memory is illustrated in this subsection.
The workflow takes into account the following main tasks, see Figure 7.1:

- T_0: Requirements analysis (RA)
- $T_{1:}$ Classification and creation of taxonomies
- $T_{2:}$ Conceptualisation and creation of ontologies
- $T_{21:}$ Thesaurus
- $T_{3:}$ Analysis and design based on UML diagrams
- $T_{4:}$ Connectivity
- $T_{5:}$ Software deployment
- $T_{6:}$ Test and deployment of application

The requirements analysis is the first step in any software project. It is in this step that the goals, structures, functionalities and services being expected from the software tool are launched. The classification and creation of taxonomies, as well as the conceptualisation and creation of ontologies, are specific activities for the set up of an organisational memory. The analysis and design is a usual step during software deployment, and we make use of the Unified Modelling Language to achieve it. The connectivity is concerned with the protocols and links required such that the Organisational Memory is open to any data format that could be received or could be send externally. Actually, either the implicit or explicit messages exchange is currently made through XML. The deployment of the Organisational Memory tool and the test and deployment of the application are necessary steps for the development of any software.

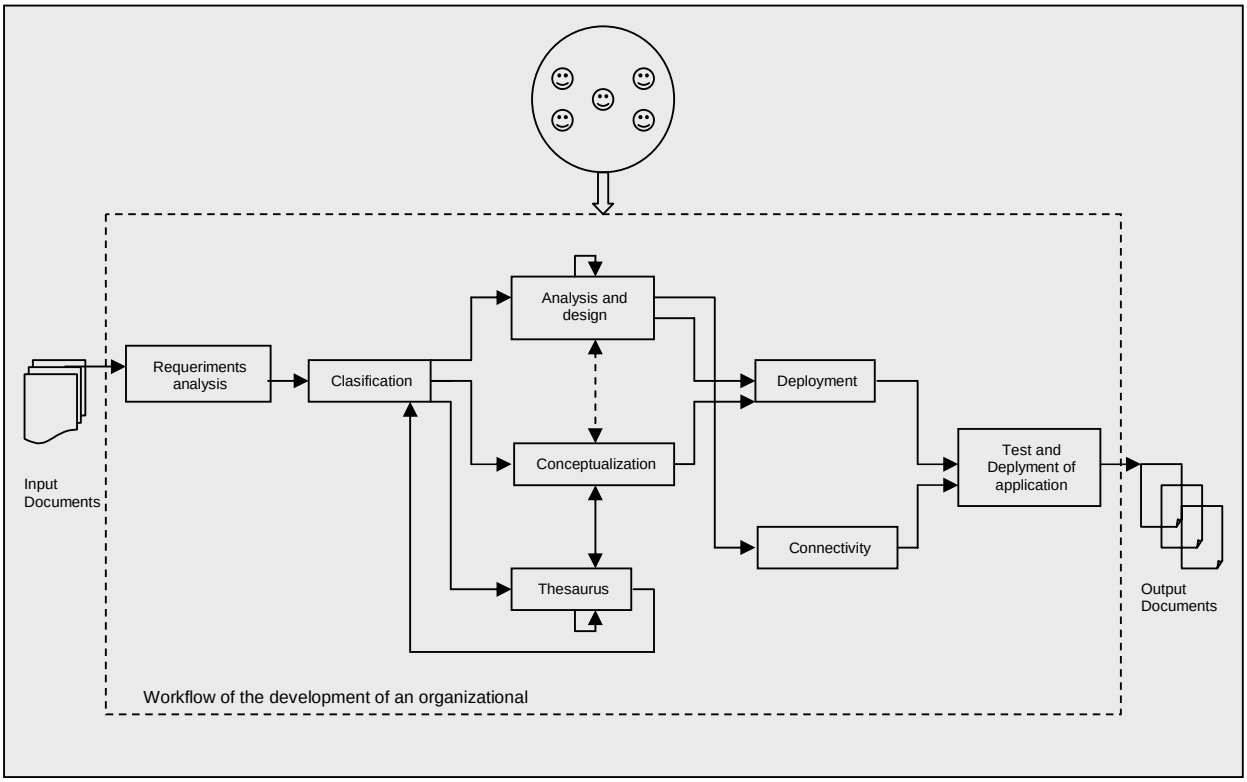

Figure 7.1 Workflow, team work and documents

7.1.2 Input/Output information

Each of these activities has input and output documents. Roughly, for the requirements analysis the documents contain the requirements and problems to be solved by the application of the tool (the OM in this case); the classification and conceptualisation require most of the information about the organisation's work and aims to arrange this information so that the added value associated to reuse is turned to the advantage of the organisation; the input for analysis and design is the split of the whole problem from the viewpoint of application making; the step of connectivity entails the specifications of the input/output data from/to the legacy applications and frameworks that eventually will provide/receive information; the software deployment and test receive, respectively, the application detailed specifications and data input to be processed. On the other hand, the output information for each task is reflected by its own name, see Figure 7.2.

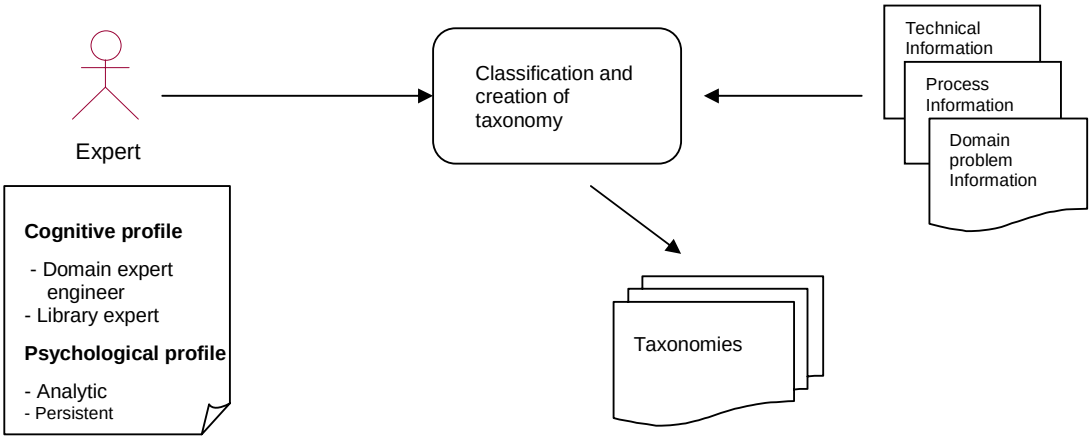

Figure 7.2 Task and the I/O Information

7.1.3 Profile of participants

Most of the participants are computer engineers and the rest are computer scientists and library experts. Thus, the cognitive profile is well known for the people doing the RA, analysis, design, and deployment as well as the testing and deployment of the application of the software tool. The classification and creation of taxonomies, in addition to the conceptualisation and creation of ontologies, is oriented by the scientists and the annals experts. Specific psychological profiles are required for each task: social and amiable for the RA step; analytic and persistent for the classification, design, connectivity and deployment steps; creative and flexible for the conceptualisation and creation of ontologies, see Figure 7.3.

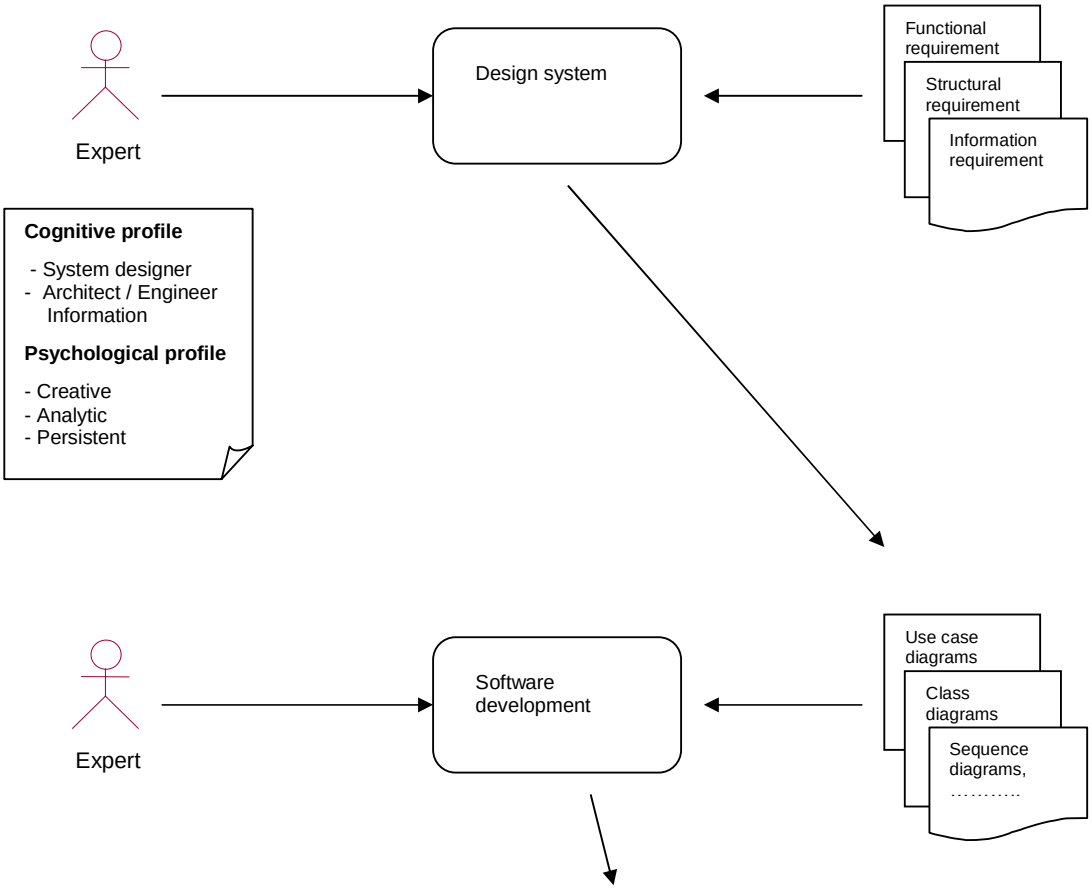

Figure 7.3 Task and the participants profile

Conclusions

The representation of workflow, participant's profiles and the rationale of the decision making process have been introduced as parts of an Organisational Memory. The added value of our proposals is the consideration and explicit representation of the information related to decision-making as a major component of the recorded experiences. In particular, the information model includes documents, supporting activities, decisions rationale and the profile of the participants. The workflow and the decision-making are considered as dynamic entities, reflecting the evolution of the work process components.

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