

# Engineering Knowledge-Intensive Tasks in Public Organisations

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**Abstract.** Public organisations often face knowledge problems due to the continual and pervasive movement of staff between units and department. The Pellucid project is developing a knowledge management system to assist in such situations. This paper describes the knowledge engineering and the knowledge level modelling undertaken in Pellucid. We use CommonKADS task templates as a mechanism to identify and derive knowledge-intensive tasks related to mobility in public organisations. Assistance to employees in those tasks is provided by active hints, a conveyor of experience within an organisation.

**Keywords:** Experience Management, E-Government, CommonKADS.

## 1 Introduction

Organisational mobility is the pervasive movement or circulation of staff from one unit or department within an organisation to another. This is commonplace in public organisations, which may deliberately encourage it as a form of career development. It is clear that organisational mobility is not necessarily a bad thing: inasmuch as mobile employees bring fresh ideas or experience of other areas, then the organisation can be enriched. Nevertheless, inevitably these employees will find it harder to perform as effectively as more experienced (static) staff, due to their relative lack of specific knowledge. Time must be spent in gaining familiarity, and although there might be training available, these are not sufficient in themselves. It is these problems that Pellucid aims to address [12].

Pellucid uses the metaphor of an intelligent assistant who looks over one's shoulder and answers questions one might have at a particular point of work [16]. The assistant detects that an employee is working in a particular process, offering knowledge resources that facilitate her/his work according to her/his expertise. To this end, the Pellucid platform integrates technologies such as autonomous co-operating agents, organisational memory, workflow and process modelling, and metadata for accessing document repositories. The platform will be installed in three pilot sites: the management of publicly funded projects in the Mancomunidad de Municipios del Bajo Gualdaquivir (MMBG) in Spain; the installation and maintenance of the traffic light plants in the Traffic and Mobility Management Department of the Comune di Genova in Italy; and the call center for management and resolution of fixed telephony breakdowns of the

Consejeria de la Presidencia de la Junta de Andalucía in Spain. Such diversity of applications requires flexibility and adaptability as two important characteristics of Pellucid.

In this paper we describe the knowledge engineering and the knowledge level modelling undertaken in Pellucid, taking into consideration the adaptability of the system to different business processes in public organisations. The Pellucid approach consists of three phases. In the first phase, described in section 2, we model the contextual and conceptual aspects of a generic public organisation following the CommonKADS methodology [15]. Then, specific aspects of a particular organisation are included in a second phase by instantiating them to some of the generic models and by adding domain-specific knowledge, as described in section 3. Section 4 presents the final phase, which produces a detailed design taking into account implementation details.

## 2 A General Model for Experience Management in Public Organisations

In CommonKADS, the development of a system entails constructing a set of models of problem solving behaviour in its concrete organisations and application contexts. The first phase in designing Pellucid has been the development of the organisational, task, knowledge and communication models for the case of a generic public organisation.

### 2.1 Organisational Model

The organisational model describes the organisation in a structured, systems-like fashion. It includes aspects such as identification of problems and opportunity areas, organisational structure and resources. All these components come into play and interact when a new knowledge solution is introduced into the organisation.

**Identifying Knowledge-Oriented Problems and Opportunities.** In the case of public organisations, we have identified the following problems related to mobility of public employees:

- When a worker leaves the organisation or changes to another department, there is no mechanism for preserving her/his experience in the previous position.
- When a worker changes of position within the organisation, due to career progression, s/he does not usually receive training. The acquisition of the specific experience is often left to the initiative of the colleagues or the worker.
- New workers usually receive some sort of training when arriving in the organisation. The training is often planned to communicate them the specific rules and procedures of the organisation. Many relevant aspects of the position are normally left out.

These problems present opportunities that should be considered in Pellucid design:

- Capture the experience about operational processes of public employees.
- Leverage the accumulated expertise of employees.
- Make tasks more efficient and reduce wasted time in searching for information.
- Offer more efficient and uniform responses to the public from the organisation.

**A General Business Process for Public Organisations.** In general, the mission of public organisations is to serve the needs of the community [5]. Those needs are represented by a portfolio of services offered by the organisation. As business process, we have selected the processing of a generic service as illustrated in Figure 1.

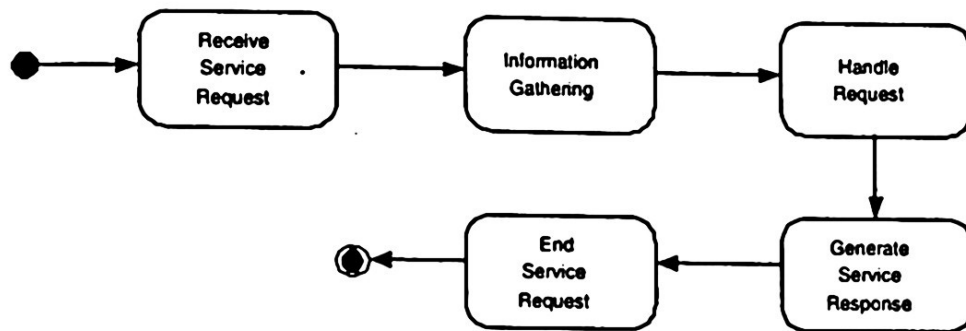


Fig. 1. Layout of a General Business Process

Receive Service Request is concerned with the reception of service request. Once a service is requested, the next action is to determine which information is appropriate to answer the request. Then, the information needed to process the request is collected. Handling a service depends on the service itself, but here we analyse typical tasks such as writing reports, assessment of the service, etc. Finally, a response is generated for the customer and the service ends.

**Describing Knowledge Resources.** Pellucid assumes that the business process of an organisation is automated with a work o w management system. The system also creates and maintains an organisational memory which contains knowledge resources. At any point of work, an employee may request assistance of Pellucid, which offers then a hint indicating which actions could be executed and which knowledge resources are useful. The following are example of knowledge resources used by Pellucid:

- **Service Directory.** Public organisations can be seen as service-oriented institutions. The business model we have developed is centred on solving a service request. Hence, having a directory of all services offered by an organisation constitutes an important knowledge resource.
- **Pro le of Activity.** CommonKADS tasks correspond to the tasks involved in solving a service request. These tasks are divided into sub-tasks we have called activities. It is important to store information about each activity, such as its time criticality, knowledge grade, description, etc.
- **Pro le of Employee.** The pro le of an employee contains information relevant for the organisation, since from there it would be possible to determine her/his expertise and knowledge. Important components are the competences, capabilities and skills of each employee.

- **Documents.** Public organisations are document-centred, so this is an important knowledge resource. This resource denotes all documents owned by the organisation. It is useful to indicate the different kinds of document available. We have identified the following kind of documents: manuals, working guidelines, work reports, assessments, meeting minutes, financial reports (spreadsheets), emails and images.

## 2.2 Task Model

In the context of CommonKADS, a task is a subpart of a business process that represents a goal-oriented activity adding value to the organisation, handles input and delivers desired outputs in a structured and controlled way, consumes resources, requires and provides knowledge and other competences, and is performed by responsible and accountable agents. The methodology includes textual templates to specify the tasks which includes information such as goal of the task, pre and post-conditions, objects handled, timing and control among others.

We have defined a catalogue of knowledge-intensive tasks that may be used in any of the tasks associated to the business process presented in Figure 1. This catalogue is based on the template of knowledge tasks proposed by CommonKADS in [15], which includes general tasks such as classification, diagnosis, assessment, monitoring, design and assignment among others. Pellucid catalogue includes the following tasks:

- **Classification of Documents.** Giving a document, this task allows one to know the classification of the document according to a topology. Such classification is useful in providing information/aid to users at any point in the business process.
- **Roadmap of Documents and Contacts Useful in a Process.** This task aims at determining which documents/contacts are useful in a particular process, when knowledge about that process is incomplete.
- **Monitoring Progress in Handling a Service.** Some processes are time-critical in the sense that the work should be done within a particular time. This task monitors the progress of such process, warning employees in case there is a risk of not ending the process in the specified time.
- **Resource Assignment.** Given the nature of a process, it could be necessary to assign some resources to it. This task suggests an employee an optimum assignment of resources to such process.

For instance, one of the most knowledge-intensive task in Figure 1 is *Information Gathering*. It requires determining the most appropriate information for the requested service and then obtaining such information. Determining the appropriate information may include generating a *Roadmap of Documents and Contacts* useful in that service. Figure 2 shows the task analysis worksheet for that task.

## 2.3 Agent Model

In CommonKADS, an agent can be human, an information system, or any other entity capable of carrying out a task. The agent model describes the characteristics of agents, in particular their competences, authority to act, and constraints in this respect.

Task Generating Document/Contact RoadMap		
GOAL	This task aims to collect all document and contacts useful in a process. We can see this task as a particular case of Information Gathering	
FLOW	Input tasks:	Receive Service Request
	Output tasks:	Handle Request
OBJECTS HANDLED	Input objects:	Service Description
	Output objects:	List of documents and contacts useful to serve service
	Internal objects:	List of activities associated to the input service Context of each activity of the input service
CONTROL	Precondition:	Input service belongs to the service directory
	Postconditions:	Documents and contacts are represented by valid links to their position in the organisational memory
AGENTS	Information Search Agent	

Fig. 2. Task Analysis Worksheet for Generating Document/Contacts Roadmap

There are three main elements in Pellucid: the employee of the organisation, a work o w system (WfMS) representing the business process of the organisation, and an organizational memory containing the relevant information of the organisation. In general, Pellucid assists the employee at any point in the work o w system by providing useful information from the organisational memory. Agents in Pellucid re ect these components. The employee is represented by the Personal Assistant Agent (PAA), which is an interface agent serving and personalising information and suggestions to the user. There is a Personal Assistant Agent per employee in the organisation. The interaction of Pellucid with the work o w system is managed by the Monitoring Agent. The whole functionality of the organisational memory is represented by three agents: the Role Agent (RA), which acts as an interface between the PAA and the organisational memory, the Information and Search Agent (ISA), in charge of searching and retrieving information from the organisational memory, and the Capitalisation Agent, which generates new knowledge in the organisational memory. Below, we summarise the main functionalities of these agents.

- Personal Assistant Agent. This agent includes functionalities such as presenting personalised information to the user, accepting comments/rating from the user about current task or selected information resource, and supporting administration of the user profile.
- Monitoring Agent. This agent informs Role Agents about activities performed by the WfMS. It includes functionalities such as providing interface for receiving information about work o w events.
- Role Agent. This agent includes functionalities such as pushing newly discovered knowledge to PAAs of interested users, handling queries from PAA, and delegating more complex or time-consuming queries from PAA to ISA.
- Information Search Agent. This agent includes functionalities such as receiving and handling queries, searching OM for document instances using generated full-text indexes, and retrieving document from a document repository and providing mechanism to PAA for accessing a given document.

- **Capitalisation Agent.** This agent creates global knowledge and reorganise historical data and knowledge data. It includes functionalities such as asserting new facts based on review of historical data from OM.

CommonKADS proposes templates for documenting the agent specifications. By way of illustration, Figure 3 shows the specification of Role Agent.

Role Agent Specification	
OBJECTIVE	Provide a user with a list of possible hints based on their current position in the business process
DESCRIPTION	The Role Agent generates active hints for the user based on her/his current context. Some of the hints could require complex queries, which are delegated to the Information Search Agent
INVOLVED IN	Context matching; Generating active hints; Sending active hints
COMMUNICATES WITH	Monitoring Agent, Personal Assistant Agent, Information Search Agent
KNOWLEDGE	This agent receives events from the Monitoring Agent indicating current activity of the user within the business process. It applies heuristics to determine similar contexts, based on activities profiles stored in the organisational memory, and to generate proper hints to the user

Fig.3. Specification of Role Agent

## 2.4 Knowledge Model

The knowledge model specifies the knowledge and reasoning requirements of the prospective system. It includes the domain knowledge model, which specifies the knowledge and information types we want to talk about in the system, and the task knowledge, which describes the goals an application pursues and how these goals can be realised through a decomposition into subtasks and inferences.

**Domain Knowledge Model.** We present here a fragment of the domain knowledge model and refer the reader to [11] for a more complete model. Most constructs of the domain knowledge model are similar to the ones used in modern object-oriented data models. Following CommonKADS, we use a notation as close as possible to UML.

In general, public *Organisations* have as mission to serve the needs of a community through a set of *Services* which consists of *Activities* and involves *Employees* [5]. Each activity requires *Skills* from the employee in order to be performed efficiently. An employee is chosen to work within a particular service on the basis of a *Role* played within the organisation. However, the role of an employee may change dynamically according to current needs. The employee who is subject to frequent changes of role within the organisation is a mobile employee (see Figure 4).

Generally, each business process can be divided into smaller steps called *Activities*. To accomplish an activity, an employee undertakes some *Actions*. It is worth noting

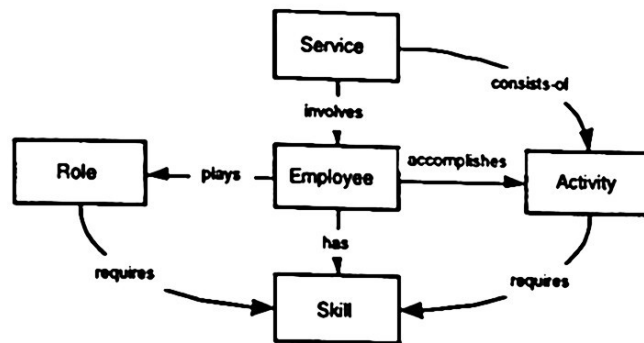


Fig. 4. Fragment of the Domain Knowledge

that actions are not part of the business process, since different people can accomplish an activity in different ways. An activity depends on the problem to be solved and such information is captured in the concept of *Context*. The purpose of Pellucid is to support and enhance employees' performance by providing them with the knowledge required by the activity they are performing at the time they are actually performing the activity. To do so, it is included the concept of *Active Hint*, a representation of experience within the organisation. Experience can be seen as knowing what to do in particular circumstances. The circumstances correspond to the context and the know what to do is characterised by the action and resources needed in that action (see Figure 5).

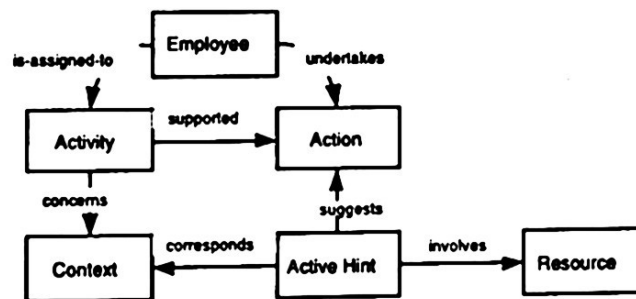


Fig. 5. Fragment of the Domain Knowledge

All elements modelled in the domain knowledge model constitute a general ontology for experience management. This ontology is used as a mechanism to express the main concepts of the system and their relation as well as to infer knowledge.

**Task Knowledge Model.** The task knowledge model defines the strategies that will be used to achieve the main goal of a task. Task knowledge is typically described in a hierarchical fashion: top level tasks such as *Generate Contact/Document Roadmap* are decomposed into smaller tasks, which in turn can be split up into even smaller tasks. At

the lowest level of task decomposition, the tasks are linked to inferences — a primitive reasoning step — and input/output functions.

Let us examine tasks *Generate Contact/Document Roadmap*. The general specification presented in Figure 2 gives an informal description of the goal of the task and the relation between input and output. It is worth mentioning there are no domain-dependent terms in such specification. This task can be seen as a particular case of an assignment task (cf. [15], chapter 6) in which we are linking (assigning) an activity to people and document resources taking into consideration some constraints such as the grade of knowledge of people — their expertise — and the relevance of the documents used. The method used to realise this task is summarised in Figure 6. In this method, decompose, determine and assign correspond to inferences. They are implemented using the ontology presented previously in the domain knowledge model. obtain and present correspond to input/output functions.

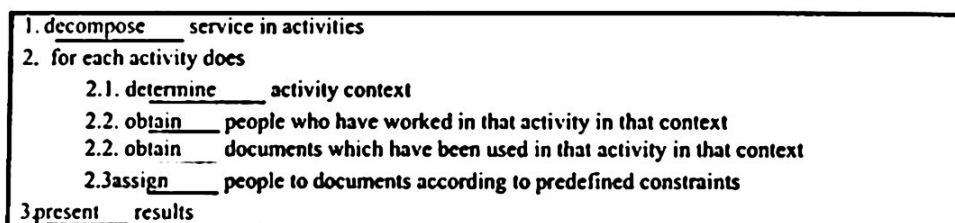


Fig. 6. Task Method of Generating Contact/Document Roadmap

## 2.5 On Active Hints

The idea of knowledge delivery through active user support, triggered according to the context in a work o w, was developed by the DECOR project [2]. Pellucid has borrowed the idea of active hints as conveyors of experience, and is working it out in a somewhat different direction: active hints are regarded as suggestions to the user to perform some actions that will assist her/his current activity.

An active hint is triggered in a context and includes an action, a knowledge resource and a justification for the hint. The context is determined by the particular activity that is carried out at that time in the work o w system. An action corresponds to an atomic act on the knowledge resource, for example use a document template, read a document or consider a contact list. The justification gives to the user a reason for the hint. The following is an example of a possible active hint in the context of a proposal evaluation when managing a project (see Figure 8).

**Context:** Proposal Evaluation  
**Action:** Consider  
**Resource:** List of People and Documents  
**Justi cation:** People in the list have evaluated similar proposals in the past, and they have used the associated documents for such activity

The catalogue of knowledge intensive tasks presented previously has a dual purpose in Pellucid. They could be subtasks of the business process, for instance *Classifying a Document* could be a task of the process of managing a project, or they could be used as internal tasks to generate active hints, for instance task *Generate Contact/Document Roadmap* was used to generate previous active hint.

## 2.6 Communication Model

The communication model specifies the information exchange between the different agents. We begin with the identification of the conversation between agents, derived from the task and agent models. At this level, every conversation consists of just one single interaction and the possible answer. For instance, Figure 7 illustrates the template describing the conversation between Monitoring Agent and Role Agent.

M/RA Conversation	
OBJECTIVE	Inform Role Agent about an event in the workflow management system
DESCRIPTION	Monitor Agent informs Role Agent about an event in the workflow system. The event contains additional information added by the Monitoring Agent, indicating some particular aspects of the current context
AGENTS	Monitoring Agent; Role Agent
BEGINNER	Monitoring Agent
PRECONDITION	Event contain information in a predefined format Occurrence of event is already stored in organisational memory

Fig. 7. Conversation between Monitoring Agent and Role Agent

Next, we model the data exchanged in each conversation by specifying speech acts. All this information can be collected in the form of sequence diagrams. We do not emphasize on this part due to lack of space.

## 3 Modelling a Specific Business Process: Project Management in MMBG-Spain

The Mancomunidad de Municipios del Bajo Guadalquivir (MMBG) is an organisation created by eleven local authorities with the main objective of contributing to the social and economic development of an area with 250,000 inhabitants in the southern Region of Andalusia (Spain). The particular problem of MMBG is the wide range of tasks that must be handled by its employees. This variety of areas in the working environment requires a high degree of flexibility among the employees, and expertise is scarce and very valuable. In this situation, the need for knowledge capitalisation and for reuse of previous experiences is very critical, as it would lead to an increase of the efficiency and would allow for a better use of the human and technical resources.

### 3.1 A Business Process for Project Management

The pilot application that will be validated at the MMBG concerns the Management of publicly funded Projects among this complex organisation. This will include all the tasks to be performed from the very early stages of the project to the justification of the project's costs and activities, and the preservation of all the documents generated during the project execution. Figure 8 illustrates the business process for project management at MMBG.

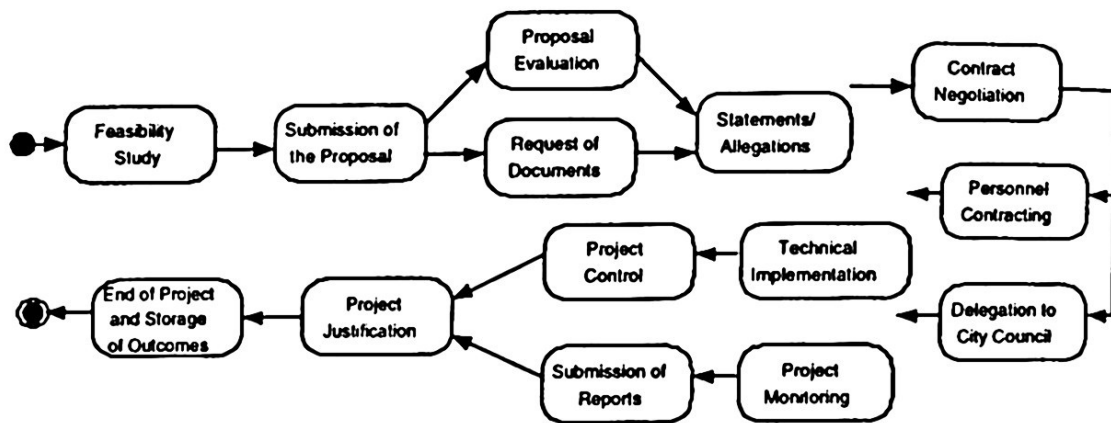


Fig. 8. Business Process for Project Management at MMBG

### 3.2 Identifying Knowledge-Intensive Tasks

The specific business process of an organisation is an aid in identifying knowledge-intensive tasks within the organisation and deriving possible hints to assist employees in these tasks. For the business process of MMBG, presented in Figure 8, the most knowledge-intensive tasks are *Feasibility Study* and *Proposal Evaluation*.

Determining which tasks are knowledge-intensive is part of the knowledge-elicitation process, and includes the participation of domain experts. In our project, we have made use of techniques such as interviews and questionnaires for both identifying knowledge-intensive tasks and deriving possible hints. In a second phase, we plan to use protocol analysis techniques to validate the hints proposed to the user and to capture new ones.

### 3.3 Domain-Specific Knowledge

Another important aspect in developing a knowledge-based system is the inclusion of domain-specific knowledge. We have constructed domain-specific ontologies for each of the participating sites, following techniques as the one presented in subsection 2.4. These ontologies have been merged with the main ontologies, allowing the system to reason about specific knowledge in the organisation. This process has been assisted with the aid of the Protege tool [13].

## 4 Artefact Modelling

The artefact modelling is concerned with the design, a specification of the software system based on the information provided by the previous models. It can be seen as a bridge between the application domain and the resulting system. Figure 9 illustrates the general architecture of our system using the traditional Model-View-Controller (MVC) metaphor [10]. The Monitoring Agent corresponds to the *Controller Module*, capturing inputs from the work o w management system bu means of its sensors and using an event-driven control regimen. The arrows in Figure 9 indicates information o w, then the Monitoring Agent informs the Role Agent about received events and updates the Organisational Memory. The Personal Asistant Agent corresponds to the *View Module*, managing the information provided to the human user by applying personalisation techniques. The core of the system is the *Application Model Module*, which comprises the Role Agent, the Information and Search Agent and the Capitalisation Agent. This module includes the functions and data that together deliver the functionality of the application. Ontologies and dynamic data manipulated during the reasoning process are also considered to be part of the organisational memory.

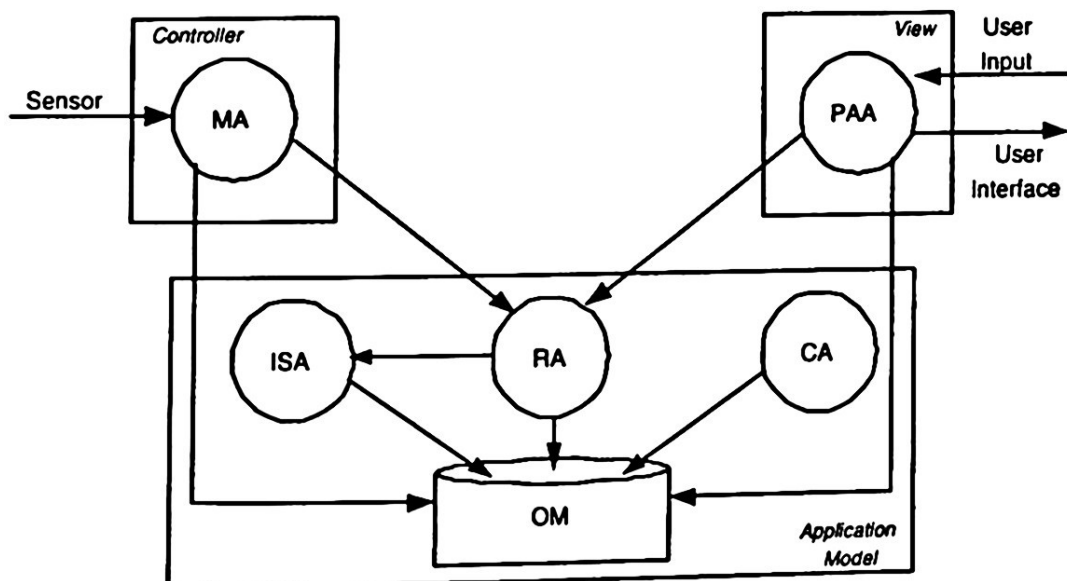


Fig. 9. General Architecture of Pellucid

We have selected Java as the programming language for the implementation of agents. The ontologies presented in subsections 2.4 are represented in the OWL ontology language; such transformation is carried out with the aid of the Protege tool [13]. The whole reasoning process makes use of the Jena 2 toolkit [6].

The nal step in the design is to detail the architecture's components. As a way of illustration, Figure 10 presents a fragment of the detailed design of the Role Agent.

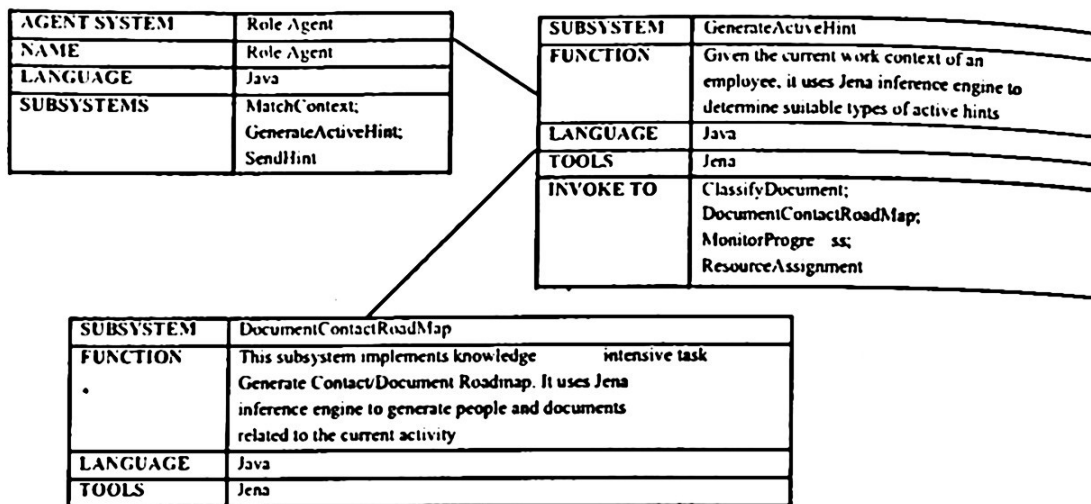


Fig. 10. Detailed Design of the Role Agent

## 5 Related Work

Pellucid has developed an approach highly influenced by the CommonKADS methodology [15], adapting elements of other approaches such as management of organisational memories [8], experience management [4] and active hints [2].

Pellucid can be seen as an example of an Electronic Performance Support Systems (EPPS) [7], systems that aim to support and enhance users' performance by providing them with the knowledge required by the task they are performing at the time they are actually performing the task. Other examples of EPPS are the EULE system [14], the VirtualOffice and KnowMore systems [1] and integration of knowledge and business processes [16].

The EULE system aims at offering assistance in the office work in the domain of insurance business [14]. It includes a business-process modelling framework which starts with a high-level structure of business processes that span various organizational units, and then gets broken down into more and more local views which at the same time become more detailed, until at the most detailed level EULE office task representations are obtained. The system is coupled with a workflow system by linking a EULE office tasks to working steps of a workflow. When reaching a working step that is associated with a EULE task, the user can request EULE assistance and obtain then the information missing at that specific point.

The VirtualOffice and KnowMore projects aim to support knowledge-intensive activities by providing automatic access to relevant information [1]. Each activity belongs to some comprehensive business process which is explicitly modelled and enacted by some WfMS. The activities are to be supported based on an available information space, which contains information sources of various types and characteristics together with suitable access structures. A central component is an intelligent assistant, which bridges between the information space and the knowledge-intensive activities and performs a process identification job (similar to the context identification job carried out by Pellucid) in which the system detects the particular circumstances of a process. The Virtual

Office tool integrates paper-based information into work o w using a document management system for information extraction, following a request from the work o w. The KnowMore project focuses on delivering goal-specific information in a proactive way by analysing the incoming stream of information that the organisation receives. These works were further extended in the DECOR project [2].

The work of Staab and Schnurr in [16] is close to our work in putting an intelligent assistant to work within a business process environment. It also exploits the inferential power of ontology-based retrieval on top of the Ontobroker software, using a notion of context-based views for coupling work o w and retrieval. In building the information system, they start with an analysis process that explores the interdependence among the documents employed in the business process. Then, domain-specific information is added by including domain ontologies describing the content of documents, and contextual information. During the execution phase, the system acts as facilitator for sharing, creating and retrieving knowledge, providing users for active help as a response to their request.

## 6 Conclusions

This paper has presented the knowledge engineering modelling undertaken in Pellucid, using the CommonKADS methodology. The main contribution of the paper lies in presenting and applying a set of knowledge-intensive tasks useful for experience management. Task typologies have been introduced previously in the literature in a more general context [3, 9, 15]. We have been inspired by CommonKADS typology, adapting some tasks for the case of organisational mobility in public organisations.

An important feature of Pellucid is the use of active hints to deliver knowledge to the members of an organisation [11]. The knowledge-intensive tasks we have proposed have been used either to solve knowledge-intensive problems within the business process of the organisation or as a mechanism to derive active hints.

Future work includes extending the tasks catalogue to include other tasks related to organisational mobility. We are currently working on the implementation of some of the tasks using semantic web technologies such as RDF and OWL, with the aid of the Jena toolkit [6].

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