



Pellucid

A Platform for Organisationally Mobile
Public Employees

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Table of contents

1	Introduction	3
2	The general aims of Pellucid	5
3	The Pellucid pilot sites	7
3.1	Comune di Genova (CdG/MTP).....	7
3.2	Mancomunidad de Municipios del Bajo Guadalquivir (MMBG)	7
3.3	SADESI	8
4	Experience management in Pellucid	10
4.1	General observations	10
4.2	The experience management life cycle.....	10
4.3	Some issues associated with experience management	11
4.4	Related experience management models.....	12
5	The technological bases of Pellucid	14
5.1	Java technology	14
5.2	Ontologies.....	14
5.3	XML, RDF and OWL.....	14
5.4	XML and XSLT.....	15
5.5	XML-RPC.....	16
5.6	Protégé	16
5.7	Jena	16
5.8	MySQL	17
5.9	Indexing systems: Lucene.....	17
6	The achievements of Pellucid.....	18
7	Dissemination and exploitation	19
8	Factual summary	21
9	Perspectives	22
10	Conclusions.....	23
	Annex A: List of deliverables	24
	Annex B: List of presentations in conferences, workshops and exhibitions	25
	Annex C: List of publications	25

Executive summary

To be completed for the final version of the deliverable.

1 Introduction

The Pellucid project has been a project under the Information Society Technologies (IST) programme of the European Fifth Framework Programme. It fell within Key Action I of the work programme, 'Systems and Services for the Citizen', and within that Action Line I.3.1, 'Intelligent environment for public sector employees at all levels'. Its fundamental objective was to develop an adaptable software platform for assisting organisationally mobile employees through experience management, and to demonstrate and validate the platform at three pilot sites. This platform is applicable in other organisations with experience management needs.

The Pellucid project had a duration of 34 months (originally 32 months but extended by a further two months, without change to the budget or funding). It had nine partners (originally eight, but one joined during the course of the project, effectively replacing another). These partners are:

1. CCLRC (UK): research institute; project coordinator
2. Softeco (Italy): IT services and solutions provider
3. Cyfronet (Poland): research institute
4. Sadiel (Spain): IT services and solutions provider
5. Slovak Academy of Sciences, Institute of Informatics: research institute
6. Consejería de la Presidencia, Junta de Andalucía (Spain): regional government; role taken over by partner 9
7. Comune di Genova, Mobility, Transport and Parking Directorate (Italy): branch of city administration
8. Mancomunidad de Municipios del Bajo Guadalquivir (Spain): grouping of local authorities
9. SADESI (Spain): IT service provider for partner 6; joined project to take over their role.

Partners numbers 6 to 10 were the end users and provided requirements, testbeds and validation for the project. The industrial partners 2 and 4 acted as interfaces with the end-users in their respective countries, as well as contributing development and customisation effort. The research institute partners provided innovation and development effort.

The project was organised in ten work packages:

WP1: Analysis of public sector working environments and tasks

WP2: Definition of generic system architecture

WP3: Development of the interaction layer

WP4: Development of the process layer

WP5: Development of the access layer

WP6: Development of the organisational memory

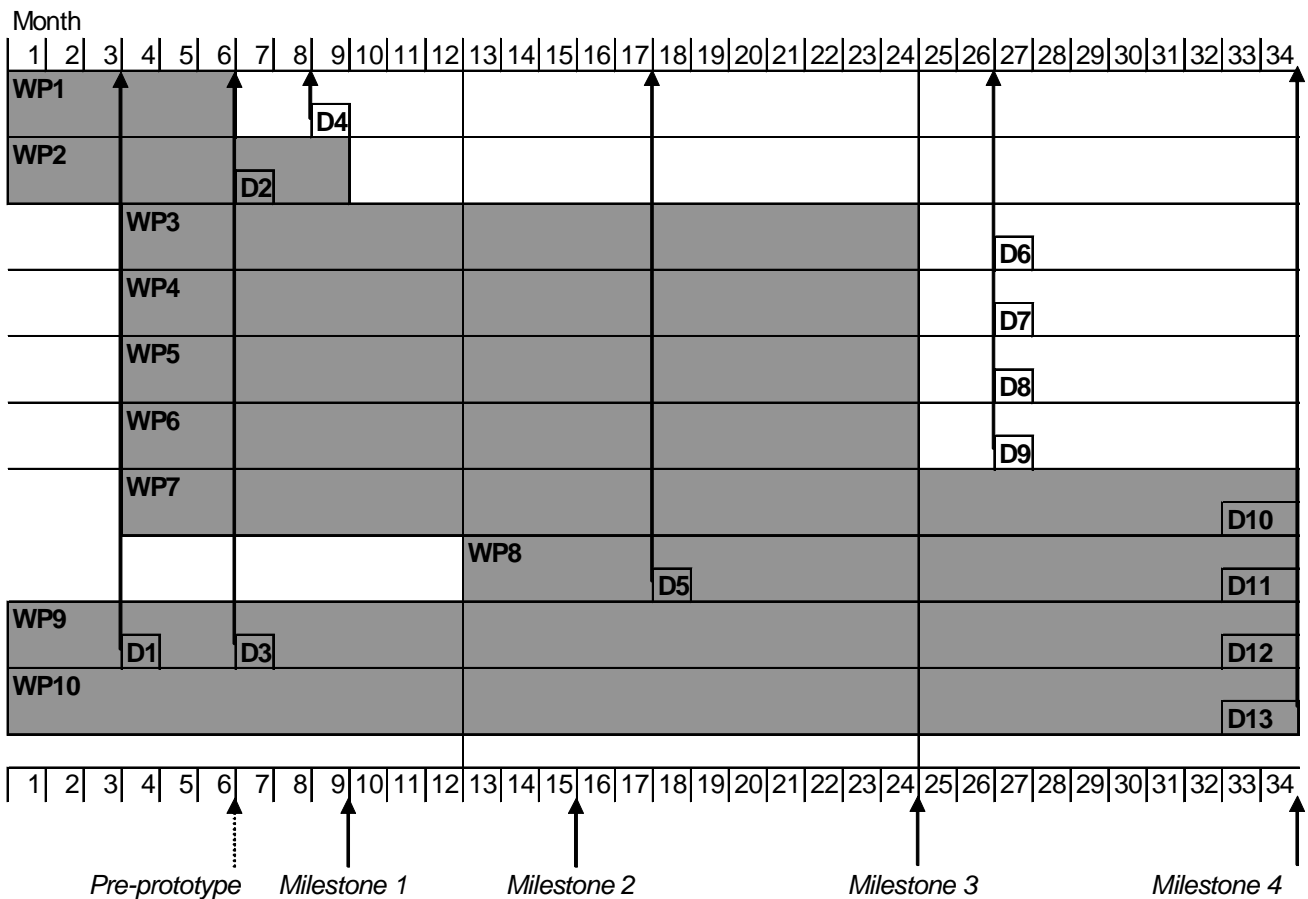
WP7: Integration of the framework

WP8: Pilot site customisation, operation and evaluation

WP9: Dissemination and implementation

WP10: Project management

Each of these had one or more deliverables and milestones. The barchart for the project in its final form, taking account of the two-month extension, is shown below.



The full list of deliverables is given in Annex A.

The remainder of this report describes the aims of the project in more detail, followed by a description of the characteristics of the three pilot sites in terms of working environment and experience management needs. The project’s model of experience management, developed and refined in the course of the project’s life, is summarised, and the technological bases of the platform are outlined. The achievements with reference to the initial objectives are described, and there is a section devoted to the plans for exploitation, a key part of an IST project. There is a brief summary of the ‘facts and figures’ of the project and a more discursive section on perspectives including innovative aspects, unexpected issues in the project life, etc.

2 The general aims of Pellucid

The Pellucid project was aimed at producing systems to assist public employees in the performance of their work. This assistance is provided through *experience management*, the accumulation, transmission and maintenance of knowledge that is acquired by individuals in the course of their work. According to Bergmann (*Experience Management*, Springer, 2002), experience is ‘specific knowledge in a certain problem-solving context’. This knowledge can include:

- Knowledge of what to do in particular circumstances, for example unusual or problematic situations.
- Knowledge of which documents are relevant to the task in hand, and where to find them (because Pellucid is dealing with organisations and processes that are fundamentally structured around the production and consumption of documentation).
- Knowledge of who has done certain jobs before, who can help, who knows things that the individual does not.
- ...

It is this kind of know-how that distinguishes the experienced employee from the novice, and translates into effectiveness, efficiency and security in the job.

In fact, the project envisaged benefits in two areas, the organisational and the individual. The organisation’s effectiveness and efficiency should be enhanced by formalisation, recording, storage and preservation of experience and knowledge. When experienced workers leave a job a large part of their knowledge is lost, and this is a loss for the organisation as a whole. Individual employees should be supported workers during integration in a new department by giving access to specific knowledge and experience accumulated in the past. The time spent to gain familiarity with the new job is often long and stressful for the worker, and is a loss for the organisations which spend money to train people.

A priority for the project was *organisational mobile* employees: those who move, as a normal part of their career progression, to different departments or units in a sector where they do not necessarily have direct experience. This phenomenon is becoming increasingly common in public organisations, and offers both opportunities (introducing new perspectives and ways of working) as well as drawbacks (loss of experience).

It is certainly true that knowledge management is by no means a purely technical problem, and that organisational and cultural issues play as much of a part in the success or failure of knowledge management endeavours. The Pellucid project aimed at ‘low profile’ knowledge management, introducing enhancements to the workers’ environment that would provide them with the benefits of experience management and encourage them to share their experience, but without a total change in the way of doing things. As the Description of Work put it, the Pellucid system ‘will support needs and capabilities of employees, but without disrupting existing practices and systems.’

Turning now to technical aspects, the Pellucid platform was envisaged as an adaptable software environment based on a multi-layer agent architecture incorporating an organisational memory. Its fundamental purpose is to extract, store and share information from the working procedures and knowledge of individual employees at different organisational levels in such a way that this information can be used in a convenient way to assist other employees in similar positions in the future.

The Pellucid system architecture is organised in three layers, the Interaction Layer, the Process Layer and the Access Layer. The aim was to develop the components of these layers—envisaged as software agents with defined roles and communications—so as to fulfil the experience management

requirements. The following diagram shows the links between the Pellucid core, of which the layers are a part, and the outside world.

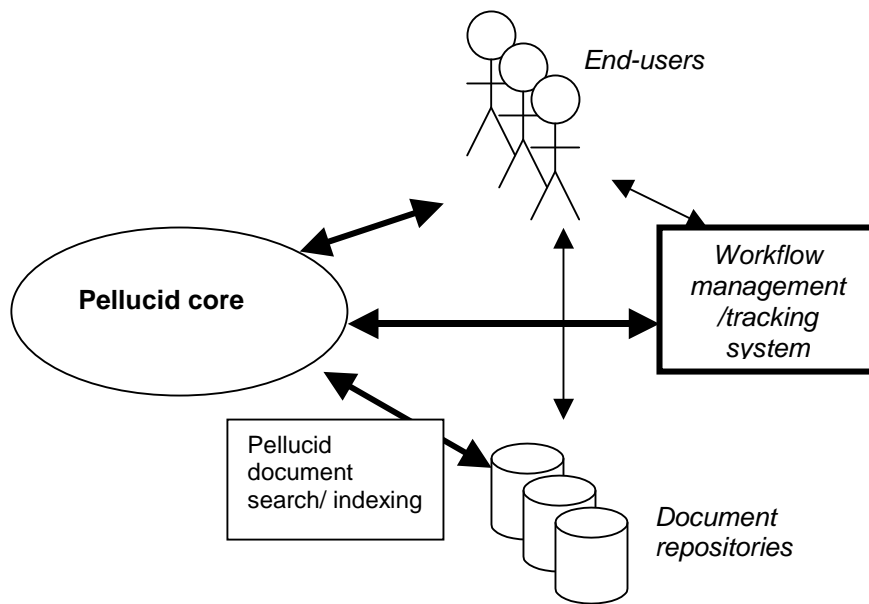


Figure 1: Schematic diagram of Pellucid system components

Key elements of the Pellucid core are:

- Personal assistant agents interacting with the employees, providing suggestions and advice, and acquiring knowledge of good practice from the employee.
- Role and task assistant agents flexibly configurable to correlate processes with available information in the context of the employee's task.
- The access layer responsible for flexible search and retrieval of diverse kinds of 'documents'.
- The organisational memory storing events that have happened as a basis for generation of advice and for analysis and enhancement of processes.

A number of important issues requiring advancement were identified. They are:

- Representation and storage of disparate organisation knowledge, including its context.
- Abstraction from patterns of performance and communication to update the organisational memory, and then to lead to enhancements in processes.
- Correlation of organisational knowledge with concrete documents, both online and offline, allowing search and retrieval according to diverse and possibly fuzzy criteria.
- Accumulation and storing of expertise, suggestions, tips and tricks, common problems and solutions, and all information items that is typically owned by 'experienced' people.
- Methodologies for acquiring knowledge and expertise from workers in order to store it and to make it available to successors.
- Methodologies and tools to actively provide the accumulated knowledge to new workers.

As will be seen in the following sections of this report, these aims, at a rather high level, were refined and made more precise by the reality of the pilot applications and by the progressive construction of the model of experience management that underpins the developments in the project. Nonetheless the project team believes that the aims expressed above, both organisational and technical, have largely been achieved.

3 The Pellucid pilot sites

The user partners in the project are responsible for making available a pilot site and application, providing access to their employees for requirements and evaluation, and hosting the Pellucid system in operation. Clearly the pilot sites have a very profound influence on the direction of the project since they provide the real-world experience management environments.

3.1 Comune di Genova (CdG/MTP)

Mobility, Transport and Parking is a Directorate of the Comune di Genova (city administration); it has a complex structure, composed of the Planning sector, the Control Strategy sector, the Public Transport sector and the Parking sector. The Planning sector is involved in traffic and mobility planning with particular regards to the definition, implementation and adaptation of traffic framework plans; moreover it is interested in the planning of signalling and in mobility resource allocation. The Control Strategy sector's activity deals with the control and management of technical systems (traffic lights, VMS plants, etc) and of road network. The Transport sector operates in the field of the public transport systems (new city bus lines, bus stops, etc). The Parking sector co-ordinates the design and management of parking areas (timetables, parking rates, etc). The operational level of CdG/MTP's activity is managed by operational units, aimed at carrying out the traffic and mobility policies defined by the sectors.

The selected work process for the Pellucid project was the process of installation and maintenance of a Traffic Light Plant. This process comprises several tasks, almost consecutive, that start with the request for installation of a new traffic light and terminate with the installation and final testing of the plant. The procedure can also quit with the rejection of the request at various steps.

The main phase includes the initial Registration of the request, which is assigned to a technician in the department. The design activities start with a Preliminary Analysis that involved the collection of several informal evaluations of the proposed plant from several actors including Urban Police, Technicians of the Department and Local Councils. The analysis of previous related requests is performed as well. The next phase is the Data Collection, during which traffic data are recorded and assessed. This task can require the work of several actors. These data are used for the Design, which involve both the technical and the economical evaluation of the plant. This phase involves several internal actors providing among others traffic simulation and updated cartography. Several versions of the plant design can be prepared up to the approval of the final one that is submitted to a formal External Evaluation. In this phase an official evaluation is asked to a set of bodies including Urban Police and Local Councils. These evaluations are used for the final assessment and the decision of continuing with the installation. If the result is favourable, an Administrative Procedure is started. The goal of this procedure is to obtain the formal approval and to identify the company for the realisation of the plant. The responsibility of the Department includes also the management of the last two tasks: Installation supervision and final Testing.

This process involves internal actors and external actors. The external actors have to be contacted for informal and formal evaluation of the proposed plant and for obtaining various type of information. It can be seen that the process is complex, and involves many actors and documents. A rigid workflow management system is not appropriate. Although the organisational mobility is generally low, there is a need for experience management owing to the complexity of the process. The knowledge life cycle is important, with knowledge accumulation and validation.

3.2 Mancomunidad de Municipios del Bajo Guadalquivir (MMBG)

The Association of Local Councils 'Mancomunidad de Municipios del Bajo Guadalquivir' has been created by eleven local authorities of the provinces of Cadiz and Seville in the south of Spain with the main objective of contributing to the social and economic development of an area with 250000

inhabitants. It is an association of eleven local public units designed as Local Development Agencies where many public employee work in the role of assisting, training and supporting local entrepreneurs who could benefit of the results of this proposal application.

For achieving the general objective, it has developed local strategies, including the following approaches and particular activities:

Optimisation of human resources by means of setting up measures to create employment. Programme of services made up of the employment, workshop school and houses of occupation, professional actions, occupational vocational training, design of new technologies, services of sensitising and development of pilot project over community initiative, programmes managed directly from this area.

Support to the creation of business initiatives and aid to their consolidation. Action of modernisation and diversification of the productive system, promotion and strengthening of the business infrastructure and support for the development and consolidation of the new business initiative, creation of infrastructures directed at the development of emergent sectors. Projects of collaboration and cooperation between businesses, advice to the self-employed.

Management of joint services that contribute to greater profitability of the resources. Projects of recovery, recycling, change of the culture in environment theme, projects of collaboration with frontier areas (North Africa), design of specific and sector-related plans.

Innovation and technology services. With the aim of creating a new culture for innovation, identifying weaknesses, opportunities and needs within the region in relation to technology and innovation, and creating a sustainable mechanism to monitor and assist innovation activities and to assist SMEs in technology transfer and R&D links.

MMBG selected for its pilot applications the process devoted to the management of projects and services. The "Funded Project Management" procedure selected for the Pellucid application, starts with the Feasibility Study that prepares the original proposal. This study is submitted to the funding body that can either approve it or reject it. In some cases, additional documents can be requested. In case of rejection a statement can be prepared to request further evaluation. After the approval, the contract is negotiated and the activity launched. Execution includes two paths: internal and external. The internal path starts with personnel contracting and technical instruction. Afterwards, the following activities, which run in parallel are planned in order to monitor and control the project implementation: Project Control, Action Follow-Up, Budget Monitoring and Corrective Action Implementation. The project is implemented by a Local Administration. This procedure follows the external path that includes: Delegation to City Council, Project Monitoring and Reporting. The two paths join at the project termination when two final tasks are planned: Final Project Justification and Storage of Outcomes.

Although there is moderate organisational mobility, more important is the effective mobility that arises from employees having to handle a wide range of tasks. This makes it difficult for them to develop deep experience in any one task. This particular process is flexible, and a rigid workflow management system is not appropriate. As for CdG/MTP, accumulation of knowledge is important, and also advice from past cases, capitalising on past experience.

3.3 SADESI

SADESI is a 100% public company created by the Junta de Andalucía in July 2001, with the strategic objective of leading the management, technical assistance, development, implementation and exploitation of the telecommunication infrastructures, information systems and Information Society advanced services.

The pilot application selected for the Pellucid project is a call centre for problems with fixed telephony systems for the Junta de Andalucía. This call centre is operated by SADESI. It is well known that agents of call centres suffer from a very high degree of mobility. The usual period of employment of the employee at the same workplace is approximately six months, as an average. This provides a good environment for testing the benefits of the Pellucid system.

This application focuses on a well defined process already managed with help of a workflow management system. The procedure starts with the income of a User Call to the centre. The call is codified and the complaint is used to generate a Request of Intervention for the telecommunication provider service. The operator can reject the request or send an Acknowledge Receipt. After the restoration of the fault, the operator sends an Answer Bulletin to the centre explaining the actions it has taken. This bulletin is notified to the user that can accept or reject it. In case of acceptance the Breakdown is Closed. If it is not accepted a cycle can start, which includes an updated of information to the operator and an updated feedback to the user. When the problem is finally solved the operator issues a Closing Bulletin that is Verified and approved by the user.

As has been said, there is a high degree of organisational mobility. There should be benefits from assistance to individuals and giving active support in the process. The work process is not dynamic, and is supported by the workflow management system Vantive.

4 Experience management in Pellucid

4.1 General observations

Experience management is a special kind of knowledge management, focusing on the dissemination of specific knowledge situated in a particular problem-solving context. It is a very wide and challenging research field, for which a general approach cannot be pursued, especially in the limited time frame of the Pellucid research project. It is necessary to select specific, and realistic, objectives in order to be able to deliver concrete results, providing benefits to public organisations and constituting a concrete step toward understanding of the general experience management topic.

Following Bergmann's book *Experience Management*, experience management in Pellucid is based on two main ideas: every employee in an organisation is both a provider and a user of experience; and employees communicate their experience to a common medium, then retrieving experience in a future from this common medium. The Pellucid system aims to be such a common medium.

Experience stored in the medium has two forms: revised and unrevised. The first form applies to elements that have been analysed and refined by knowledge administrators. They can be considered 'assessed' experience. The role of the Pellucid system is to match such elements with the current working context to identify relevant ones to proposed to users by means of the active hints approach (see below). Unrevised elements are coming from user observation or user input by means of the Free Text Note tool. They convey experience, but are not organised and assessed. The role of Pellucid is to imitate an organisation process by linking such elements with the working context and among them. Groups of similar and analogous elements are formed. These groups are then proposed to the user and are candidate for knowledge administrator assessment.

4.2 The experience management life cycle

The Pellucid experience management model comprises three phases: *Capture and Store*, *Analysis and Presentation*, and *Experience Evolution*:

- The *Capture and Store* phase is concerned with transferring experience to the common medium and deals with observing and storing experience in a particular context. There are three ways of capturing such components: observing employees' actions and workflow events; analysing documents entered into the system; and by direct input from workers. Capturing experience from working actions and events is particularly beneficial in repetitive tasks; they are used to create common patterns that can be retrieved in the future in order to assist other employees. Documents constitute an important asset in any organisation. Metadata is added to documents, enabling the system to retrieve in an automatic way documents useful in a particular working context. The direct capture of experience from employees is carried out through *free-text notes* written by the employees themselves. This constitutes a good source of knowledge, particularly in dealing with exceptions and deviations to documented procedures and situations. That is especially useful to transfer knowledge from experienced users to novices.
- 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 it. The *Analysis and Presentation* phase is concerned with providing such knowledge. To do so, the concept of an *active hint* is introduced, a conveyor of experience within the organisation. 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 by the employee at that time in a workflow system. An action corresponds to an atomic act on a knowledge resource, for example use a document template,

read a document or a note, or consider a contact list. The justification gives to the employee a reason for the hint.

When an employee is performing a task, the working context is monitored by the Pellucid platform, which try to match such context with stored ‘context prototypes’. In general, all representative contexts from the past are stored with potential solutions in the form of *hints*. Rarely (if not ever) a perfect match occurs. So the system has to *adapt* the previous context to the new one as well as the past solution. The system suggests the past solution (maybe adapted) in the form of *hint*. The user is free to follow or not the hint given by the system. The user is able to communicate this decision to the system which, upgrades a ‘relevance measure’ used to select *hints* to propose. With this approach obsolete knowledge can fade out progressively.

- The aim of *Experience Evolution* is updating the available experience. Due to the rapidly changing environment, experience may have only a limited lifetime. Invalid experience must be identified and removed or updated. To this end, the final Pellucid platform includes a set of methods and semi-automatic tools to allow knowledge engineers and expert users to update the experience stored in the organisational memory. In particular, suggestions provided can be ‘evaluated’ by the users on the basis of a simple voting mechanism.

The Pellucid lifecycle has some particular characteristics in relation to other experience management cycles. First, Pellucid is active at all times. It *monitors* users’ actions silently and gather common patterns of operation (Capture and Store Phase). Second, Pellucid tries to *anticipate* users’ problems, offering hints, even if not requested, based on the current ‘working context’. Finally, user knowledge is captured in the way of free text notes; we can see them as the ‘initial’ shape of hints that could be improved in the Experience Evolution Phase.

4.3 Some issues associated with experience management

In this subsection we explore some issues that have arisen in the project concerned to experience management.

- **Definition of Experience.** The first issue concerns with the definition of the word experience. The project tried to adopt a practical view of such word, avoiding to be attached to a particular definition. Our view is of a *common medium –Pellucid-* in which users can put and share *their* experience, like a digital collaborative library into which every one is author and reader. The active hint approach is in agreement with this view: the system is able to *store* and *fire* hints. A hint is a *conveyor* of a *fragment* of experience formulated in a way which is practical for a computer to store and manage. *Free text notes* also comply with this view. Experience is in the text entered by the user in a specific context. Pellucid acts an organiser and conveyor of such experience.
- **The Start up Problem.** Every Organisational Memory must, at first, store some content which have been collected in the customisation phase, perhaps with the help of end users. The content should be valid and form a *critical mass* after which the system is able to grow independently.

This is not necessarily a problem, but only an additional cost which cannot be anticipated in the framework, but must be part of the initial set up of the system. The framework, without set up, is fairly useless, like an operating system. It is the union “framework + setup” that creates a usable system. This setup should include background knowledge about the application domain and an initial set of hints to be extended during the system life cycle.

- **Creation of Hints.** A crucial part of this set up is the creation of hints. To be successful, it is extremely important to have a throughout knowledge of the end users’ environment and domain. Writing good domain ontology is necessary, but not sufficient.

In principle any approaches lays between two extremes: automatic and manual. The former relies solely on system reasoning capability: all input collected are analysed, with the help of suitable background domain knowledge, and hints are created from the discovering of similarities, repetitive patterns and other evidences. The latter requires experience formalisation sessions where knowledge administrators analyses lessons learnt from recent activity and creates meaningful hints. Both approaches have benefits and drawbacks, and only a mix of the two can provide effective results.

Pellucid consider both automatic and manual hint generation. In particular knowledge administrators are responsible for entering parametric hint classes, while hints presented to users are created automatically based on the actual context and the user input.

- **Context and Content.** As we mentioned before, a hint is composed of: *content*, *reason*, *context*, and *source*. The most important parts are context and content.

Our goal is to have *smart* hints (that is, hints which say intelligent things) presented at the right time. Unfortunately, smartest hints usually do not have a context which is easily expressible in machine format easily; on the contrary, hints that can be simple characterised in the context, are usually poor-content (they correspond to the class: “look at this”, “do that”...)

The best we can do in our system is to mix these two classes of hints. That is, we try to have simple hints for the newcomers, which are clearly specified in the context, even if their content is not so smart; and intelligent hints for the experts which, even if they have no a clearly defined context, are nevertheless useful because the expert will give them one.

- **Free text notes.** This feature address direct capturing of user input to be used in the active hint generation process. Basically it is a simple tool allowing users to attach notes to almost any micro-activity of an ongoing procedure they are working on. Notes are then presented to user when he is working again in the same context. That provides a simple, but helpful, support to users’ work that should foster the use of the tool (something similar to electronic Post-It notes).

The basic experience management assumption is that *Free Text Notes* are conveyor of experience fragments. These notes are expected to contain a large part of knowledge on handling exceptions, optimising the procedure and dealing with deviations, which is dynamically discovered by users. They constitute an unstructured repository of high quality knowledge. The role of Pellucid is to generate some structuring to help reusing such knowledge. To provide that, all notes entered are analysed and classified according to two similarity measures: context similarity and internal text similarity. Given the present working context, hints are created which collect all notes entered in similar context from the past. If a note is present, hints are created, which collect all similar notes, even from slight different context. These hints provides two different and complementary views of observations entered in the past.

- **Developing for the Future (Scalability, Maintenance).** As the start-up, the future of the system is also a problem. First, the system should be able to forget; otherwise, the database will grow too much and performance will degrade. Second, periodically a person should adapt the system to the changes in the organisations. Hints may become old; some facts could be not true any more; people want to add their personal contribution to the database and so on.

All these aspects are analysed and developed in the Experience Evolution Phase.

4.4 Related experience management models

One of the influential works in the definition of the Pellucid experience management model is Bergmann’s book, references above. Bergmann’s experience model consists of a *Knowledge Kernel*, a *Problem Solving Cycle*, and a *Development and Maintenance Methodology*. The *Knowledge Kernel* contains the experience base and the reuse-related knowledge as well as the

vocabulary on which both are based. The *Problem Solving Cycle* describes problem solving that is supported by experience reuse; it includes steps such as problem acquisition, experience evaluation and retrieval, experience adaptation, and experience presentation. The *Development and Maintenance Methodology* addresses the acquisition and maintenance of the knowledge in the knowledge kernel as well as the technical, organisational, and also managerial aspects of the problem solving cycle and its implementation. Bergmann's Knowledge Kernel corresponds to Pellucid's organisational memory, the repository storing the experience, data and metadata needed by the systems. Some actions of the Capture and Store phase are also linked to the kernel. The Problem Solving cycle is associated with Pellucid's Analysis and Presentation phase, although Bergmann's cycle is more general but strongly linked to case-based reasoning. The active hint approach has the advantage that it can be attached to several reasoning techniques. Finally, the Development and Maintenance Methodology is related to Pellucid's Experience Evolution phase.

5 The technological bases of Pellucid

5.1 Java technology

Java technology is chosen as one of important pillar of Pellucid due to its features and support of large number of existing Java libraries and possibilities to apply and extend system flexibly. The Java programming language was also chosen because of its robustness and versatility, which have many great features such as:

- platform independent (great for heterogeneous environments)
- supporting for migration of classes,
- creating programs to run within a web browser.
- development of server-side applications, development for wireless and other consumer devices,
- XML support
- SQL interfaces to DBMS systems
- development environments available (e.g. JBuilder, Eclipse, Idea ...)

The use of Java technology is reasonable either for the future development and extension of the Pellucid platform.

5.2 Ontologies

Ontologies have become a very important aspect in many applications to provide a semantic framework for knowledge management. The huge advantage of ontologies is not in processing, but in sharing meaning, emergence and discovery of gaps and for improving tacit knowledge transfer. In the context of Pellucid, ontology is the main mechanism employed for the representation of information and knowledge, defining the meaning of the terms used in the agent content language and the relation among these terms. The Pellucid system was highly influenced by CommonKADS methodology, which is followed in designing parts of the Pellucid system.

For the Pellucid project, which addresses frontiers of information technology for application purposes OWL is a proper choice. The Web Ontology Language (OWL) in the recent W3C recommendation describes hierarchical relationships, property relationships, equivalent/disjoint concepts, cardinality constraints, etc. It follows the current development in semantics used for dealing with different kinds of semantic-rich data, being a W3C and Global Grid Forum recommendations for the semantic WEB and semantic Grid development respectively. Protégé is a chosen auxiliary ontology editor and Jena is a tools supporting OWL at present.

5.3 XML, RDF and OWL

XML, RDF and OWL enable the Web to be a global infrastructure for sharing both documents and data, which make searching and reusing information easier and more reliable as well.

- XML provides rules, syntax for structured documents: at the foundation, XML provides a set of rules for creating vocabularies that can bring structure to both documents and data on the Web. XML gives clear rules for syntax; XML schemas then serve as a method for composing XML vocabularies. XML is a powerful, flexible surface syntax for structured documents, but imposes no semantic constraints on the meaning of these documents.
- RDF delivers a data framework for the Web: RDF is a standard a way for simple descriptions to be made. What XML is for syntax, RDF is for semantics: a clear set of rules for providing

simple descriptive information. RDF Schema then provides a way for those descriptions to be combined into a single vocabulary.

- OWL delivers ontologies that work on the Web: that is a way to develop subject (or domain) specific vocabularies. Ontology defines the terms used to describe and represent an area of knowledge. Ontologies are used by people, databases, and applications that need to share subject-specific (domain) information. Ontologies include computer-usable definitions of basic concepts in the domain and the relationships among them. They encode knowledge in a domain and also knowledge that spans domains. In this way, they make that knowledge reusable.

RDF and OWL are Semantic Web standards that provide a framework for asset management, enterprise integration and the sharing and reuse of data on the Web. Semantic Web-enabled software using RDF and OWL include:

- Content creation applications: Authors can connect metadata (subject, creator, location, language, copyright status, or any other terms) with documents, making the new enhanced documents searchable
- Tools for Web site management: large Web sites can be managed dynamically according to content categories customized for the site managers
- Software that takes advantage of both RDF and OWL: Organizations can integrate enterprise applications, publishing and subscriptions using flexible models
- Cross-application data reuse: RDF and OWL formats are standard, not proprietary, allowing data reuse from diverse sources

OWL provides a language for defining structured, Web-based ontologies which delivers richer integration and interoperability of data among descriptive communities. Where earlier languages have been used to develop tools and ontologies for specific user communities (particularly in the sciences and in company-specific e-commerce applications), they were not defined to be compatible with the architecture of the World Wide Web in general, and the Semantic Web in particular.

5.4 XML and XSLT

Since Java technology is chosen as background for the Pellucid system, the choice of web server (Tomcat) and implementation middleware (JSP) are reasonable. Tomcat and JSP are among the most applicable options for large commercial systems, which are required to be extensible. The Tomcat web server and JSP technology are Java-technology supported. They open the door to large number of existing Java libraries and possibilities to apply and extend system flexibly.

XML (Extensible Markup Language) is widely used language for web development; it is regarded as the universal format for structured documents and data on the Web. Therefore, in Pellucid, XML is used in various forms/degrees from description of ontology to communication content language. XML/XSLT technology permits visualization of XML documents and displaying information presented to the user by the Personal Assistant Agent. The JSTL is native Java library for XML processing. The selection of technologies used in every layer of Pellucid system is done in compliance with the whole Java-background.

XSLT is a language for transforming XML documents into other XML documents; it specifies the presentation of a class of XML documents by describing how an instance of the class is transformed into an XML document that uses a formatting vocabulary. JSTL contains Java libraries for XML processing, including parsing an XML document and transforming it using XSLT. JSTL has also expression language (EL) support. Underlying libraries for JSTL with Tomcat are: JSTL API and implementation, Jaxen, Saxpath, JDBC, JAXP API and implementation and Xalan.

In the Pellucid system, the use of XML is widespread for knowledge and experience description and format. The transformation from XML to other format is easy and customizable that gives great flexibility to the system.

5.5 XML-RPC

XML-RPC is clean, extensible and simple cross-platform distributed computing, based on the standards of the Internet. It is a specification and a set of implementations that allow software running on disparate operating systems, running in different environments to make procedure calls over the Internet. It is remote procedure calling using HTTP as the transport and XML as the encoding. XML-RPC is a portable way to make remote procedure calls over HTTP. It has implementations and can be used in various programming languages such as Perl, Java, Python, C, C++, PHP, etc. Implementations are also available for various platforms such as UNIX, Windows, Macintosh, etc. An XML-RPC message is an HTTP-POST request. The body of the request is in XML. A procedure executes on the server and the value it returns is also formatted in XML. Procedure parameters can be scalars, numbers, strings, dates, etc.; and can also be complex record and list structures. XML-RPC is lightweight protocol, extremely easy to implement, debug. The use of XMP-RPC as underlying communication protocol with web-based graphical interface in Pellucid is due to its simplicity, which is the greatest feature of XML-RPC.

There are also other possibilities such as WDDX (Web Distributed Data Exchange), SOAP (Simple Object Access Protocol), etc. These heavier weighted protocols provide more possibilities in the cost of complexity, which are not really required according to Pellucid classifications.

5.6 Protégé

Protégé is an open-source development environment for ontologies and knowledge-based systems. It is a tool supporting the construction of ontologies and it also provides an application platform for knowledge based systems and libraries for application building. Protégé is developed by Stanford Medical Informatics at the Stanford University School of Medicine with support from Defence Advanced Research Projects Agency, National Cancer Institute, National Institute of Standards and Technology, National Library of Medicine, National Science Foundation. Due to its features and availabilities, Protégé is the best-known ontology editor that supports OWL and Protégé has a large and active user community.

Protégé is not a part of in the Pellucid system, but an auxiliary tool. It is used for ontology creation and maintenance, which is one of the important backgrounds of the Pellucid system.

5.7 Jena

Jena is a leading Semantic Web programmers' toolkit. It is an open-source project, implemented in Java, and available for download from SourceForge. Jena offers a simple abstraction of the RDF graph as its central internal interface. This is used uniformly for graph implementations, including in-memory, database-backed, and inferred graphs. Jena offers a simple abstraction of the RDF graph as its central internal interface. This is used uniformly for graph implementations, including in-memory, database-backed, and inferred graphs. The main contribution of Jena is a rich API for manipulating RDF graphs. Around this, Jena provides various tools, e.g., an RDF/XML parser, a query language, I/O modules for N3, N-triple and RDF/XML output. Underneath the API the user can choose to store RDF graphs in memory or in databases. Jena provides additional functionality to support RDFS and OWL.

5.8 MySQL

Databases are used for Organizational Memory (OM) implementation. In OM, historical data, organised knowledge and experience, status and metadata are stored. Standard Relational Database Management Systems (RDBM) with SQL language is used to query and update data in OM. The current implementation is done using MySQL database due to its features such as open source, speed, scalability, reliability and availability on Linux and Windows platforms. The choice is also based on the support of Jena library.

5.9 Indexing systems: Lucene

Lucene is an open source search engine framework available from Apache.org under the Jakarta family of open source projects. Lucene provides libraries for searching and indexing of different types of files and data providers. Because Lucene is a search framework it requires developer ingenuity to build applications around it. However, Lucene ultimately provides very powerful set of search APIs. Lucene comes with two main services available: indexing and searching. The indexing tasks are done independently from the search tasks. Lucene is written entirely in Java.

Text indexing is the area of Lucene focused on building a searchable index. The index works as a repository created for high performance content queries. Lucene exposes a rich API to interact with the information stored in the index. Text searching creates a query that contains a collection of terms that the user is looking for in the index. The index repository is built for high speed look ups and the results can be returned with relevancy ranking. Lucene supports several types of searches that are common in the industry. Main search types are listed below:

- Wildcard: Lucene supports single or multiple wildcard searches.
- Fuzzy: Fuzzy searches are based on the Levenshtein Distance or Edit Distance algorithm.
- Proximity: Lucene supports finding words which are within a specific distance.
- Ranging: Range queries allow one to match documents whose field values are between the lower and upper bound specified by the range query.
- Boosting a term: Lucene provides the relevance level of matching documents based on the terms found.
- Boolean operators: Boolean operators allow terms to be combined through logic operators. Lucene supports AND, "+", OR, NOT and "-" as Boolean operators.

Lucene is a high-performance, scalable, search engine technology. Both indexing and searching features make up the Lucene API. Lucene was used in a variety of real-world use cases, e.g. Nutch - an open-source project designed to index the internet very much like Google was built upon Lucene.

6 The achievements of Pellucid

The achievements of the project have been of three kinds:

- developing a flexible and coherent model of experience management;
- implementing that model in the adaptable Pellucid platform;
- customising the platform in three pilot applications.

The experience management model, as explained in section 4, is built on the idea of *active hints*, spontaneously generated carriers of experience that are presented to the individual user according to working context. This description suggests some of the achievements that have been made: particularly the richness of the representation of working context, capable of handling both position in a work process and domain-specific characteristics of a case. The development and application of the idea of active hints, very simple in some ways but also capable of great flexibility, is a key to the project's achievement. This is illustrated by the fact that the same model has been applied in the three very different applications. The users' experience of the Pellucid system is very different in each application, but the underlying model is the same.

The Pellucid platform has been developed by the combined effort of the research institutes and industrial partners working together. Its common core is what makes the idea of active hints into a reality, and again the fact that it has been applied in all three diverse pilot applications is a testimony to its generality. Particular achievements include:

- the development of generic ontologies for modelling working context;
- the adaptability of the idea of active hints as transmitters of experience;
- the effective use of combined text-based and ontology-based indexing and searching for document retrieval;
- the flexibility of the user interface, allowing either a specialised Pellucid window or incorporation into an existing application such as a workflow management system;

With respect to the technical issues requiring advancement listed in the Description of Work and mentioned in section 2 of this report, it is a considerable achievement of the project that almost all have been achieved in some way.

Finally, the customisation of the platform in the three pilot applications has been the achievement with most impact for the end-users. Coordinated work on customisation was required to develop domain-specific ontologies, tailor the active hints to the needs of experience management, develop or adapt user interfaces, and evaluate the systems with real end-users. These systems are now ready for hand-over to the respective organisations for ongoing use and maintenance.

The final version of the deliverable will include screen shots of the three pilot systems.

7 Dissemination and exploitation

The current European trends are focused towards the conditions in the working environment. The general trend is to limit the demands that are placed on workers, which, in today's 24-hour information-driven society, are becoming ever more insistent and pressurised.

The added value of undertaking the Pellucid project at European level came from the need to demonstrate the generality across different European countries and types of public organisation. The problems, which Pellucid addresses, are common across countries, but it is necessary to show that the solutions being developed are also of sufficient generality as to be widely applicable.

Knowledge and experience management is needed by those organisations that anxious to make their know-how profitable. These are the potential customers of the Pellucid platform. More significantly, knowledge needs to be captured and organised in order to allow employees to connect with the right people and to have the right information at the right time in the right way.

The current state of the economy may suggest that it is not the best time to undertake knowledge management projects. But there are several companies that are finding success and are using knowledge management to link all the data about potential investment choices with practical knowledge about how and when to use that information. This could indicate that the practice of knowledge management can also be useful during tough economic times as well as in times of rapid growth.

Once these needs have been identified, the first step is to start with a focus on basic control over the documents and also sharing tacit knowledge. The main issues that have to be taken into account are that:

- A knowledge management plan has to map directly back to the business strategy of an organisation.
- A knowledge management plan should be designed to help solve business issues.
- A knowledge management strategy should highlight three areas: people, processes and technology.

When selecting a knowledge management system, an organisation has to consider systems that have open architectures and proven integrations into systems to ensure a successful implementation. In summary, it is necessary to have good software or a good system to capture knowledge. It is necessary to ensure that there are adequate resources to create and maintain the knowledge content.

Taking all this into account and focusing on Pellucid, it is clear that the first need for a proper commercial exploitation of the platform is to adapt it to the current challenges, trends and gaps of the addressed market. Thus, the mentioned technological and business tendencies need to be taken into account.

The competition analysis that has been performed aims to identify and give a summary description of the potential competitors of the Pellucid platform in the market, considering not only the national and European level but also taking into account international organizations. The description of each of the potential competitors endeavours to point out the similar characteristics or elements explaining why such product can be regarded as a competitor.

Two possibilities are contemplated for the future exploitation of Pellucid in the European market:

- Each partner individually addresses its own local market, assuming the commercialisation, customisation and maintenance of the product.

- The second possibility (non excluding with the previous one and that would be applied in thirds countries) would be the one of a joint operation of the partners distributing the necessary work for the exploitation (marketing, customisation, maintenance, etc.) among them.

Each partner being in charge of the system exploitation in its own country does not interfere with the setting up of a common marketing and dissemination approach for the whole consortium, especially if the partners decide to commercialise the solution in cooperation. However, specific rules for commercialisation should be agreed when establishing the business principles.

Considering the potential markets for Pellucid, the consortium decided that the best strategy was to use progressive degrees of similarity of potential applications. It is unlikely, though not impossible, that opportunistic possibilities will arise. Thus the more systematic approach was to open up markets successively, using both horizontal and vertical similarities:

The same process (e.g. installing traffic lights) in other public administrations in the same country (e.g. the Comune di Modena)—presumably much of the legislation and general practice will be the same.

- The same process (traffic lights) in public administrations in different countries (e.g. Oxfordshire County Council).
- Different processes in organisations already using Pellucid (e.g. local grant allocation by the Junta de Andalucía).
- Different processes in other public administrations - degrees of similarity could be taken into account, for example urban road planning will probably be more similar to our CdG pilot application than dealing with complaints about hospital treatment.
- Processes in private companies.

However there is also scope for each partner to develop its own 'seed' application and expand out from it.

Each partner in the project has made a study of potential customers in its national market. These studies have confirmed the great potential that a tool like Pellucid could have in the European markets with the aid from a suitable marketing strategy.

8 Factual summary

This section will be filled in for the final version of the deliverable, and will give figures about effort and budget spent etc.

9 Perspectives

The Pellucid project undeniably had ambitious goals. Knowledge management has attracted a great deal of attention in recent years, from both the sociological and technical points of view. There have been a good number of success stories, but also a sense that the importance of the endeavour is overrated. Even the more limited field of experience management has seen a diversity of approaches. Within this context, the Pellucid project as originally envisaged has several rather disparate aspects:

- A view of the importance of experience management in public organisations, and especially for organisationally mobile employees.
- Three pilot applications which at the commencement of the project were in various stages of definition, and whose commonalities and differences were not known in advance.
- A set of technical bases on which it was believed that experience management systems could be built.

Of course, individual partners in the project team also brought their own experience of developing knowledge management systems of various kinds, and therefore a reassurance that the proposed technical bases were indeed adequate.

Something that was not fully appreciated at the beginning of the project was the fundamental importance of the explicit experience management model. Although clearly the technical bases implied a model, it was vital to make it explicit so that all partners could commit to it, and especially so that the user partners could see what it was that they were going to obtain. The crystallisation of the idea of active hints, generated according to working context, was a key point in the project's life. Although the idea is not a new one—it arose in the IST project DECOR—the adaptation and use in Pellucid can be regarded as a significant innovation for developing experience management systems.

A second key point in the project's life was the bringing together of working context with experience management. If the hints are the transmitters of experience, they need to be related to the situation in which the employee is working, both for capture of knowledge and for its subsequent retrieval. The project recognised from the outset the importance of workflow and process modelling. However it was the need for the provision of such context to the Pellucid system that led to the idea of a 'workflow tracking system'—an auxiliary system that feeds the Pellucid platform with information about the current context of employees as they navigate their processes. Such a system need not be a workflow management system, though it might be; it can also be a lighter, more flexible system adapted to fluid, complex processes.

Finally, the role of the organisational memory changed over the project's life. Originally it was conceived as a basis for accumulating facts about past process instances to 'allow for monitoring of the overall behaviour of the system and a learning capability for continuous improvement'. Although this is an important aspect of an organisational memory, as the project progressed it became clear that an even more fundamental role is to store the history of events so as to be able to return experience to employees. Active hints relating to documents used or contacts consulted in the past can only function if this historical knowledge is available.

Overall, the Pellucid project achieved most of its initial goals. The envisaged work on fully automatic abstraction from patterns of performance to generate process improvements has not progressed as far as originally hoped: some work has been done, but not fully integrated in the Pellucid platform. At a lower level, the primary importance of software agents was not maintained: the agent paradigm proved useful for system design but less so for implementation. These deviations or partial achievements do not detract from the overall success of the project in

developing a platform for experience management applications, with experience in its customisation and use.

10 Conclusions

To be completed for the final version of the deliverable.

Annex A: List of deliverables

Del. no.	Deliverable name	WP no.	Del. type	Security*	Delivery (proj. month)
D1	Project presentation	9	Report + website	Pub	3
D2	Pre-prototype demonstrator	2	Software	IST	6
D3	Dissemination and Use Plan	9	Report	IST	6
D4	Environment and requirements analysis	1	Report	Pub	8
D5	First user evaluations	8	Report	IST	17
D6	Description of interaction layer agents	3	Report + software	Int	26
D7	Description of process layer agents	4	Report + software	Int	26
D8	Description of access layer agents	5	Report + software	Int	26
D9	Description of organisational memory	6	Report + software	Int	26
D10	Final integrated system	7	Software + reports	IST	34
D11	Final user evaluations and best practice guidelines	8	Report	Pub	34
D12	Technology Implementation Plan	9	Report	IST	34
D13	Final report	10	Report	Pub	34

**Int Internal circulation within project (and Commission Project Officer if requested)*

Rest. Restricted circulation list and Commission PO only

IST Circulation within IST Programme participants

FP5 Circulation within Framework Programme participants

Pub Public document

Annex B: List of presentations in conferences, workshops and exhibitions

To be completed for the final version of the deliverable.

Annex C: List of publications

To be completed for the final version of the deliverable.