Pellucid Agent Architecture for Administration Based Processes

M. Laclavik, Z. Balogh, L. Hluchy, G. T. Nguyen, I. Budinska, T. T. Dang
Institute of Informatics, SAS, Dubravska cesta 9, Bratislava 84237, Slovakia
E-mail: {laclavik.ui, balogh.ui, hluchy.ui, giang.ui, utrrbudi, utrrtung}@savba.sk

Abstract

In this paper we present how agent technology can be used to improve Administration Based Processes. We introduce Pellucid Agent Architecture, which can assist organizationally mobile public employees. The presented architecture was created as a part of the European Union IST Project named Pellucid.

1 Introduction

Platform for Organizationally Mobile Public Employees (Pellucid) is the European Project 5FP RTD IST-2001-34519. The overall objective of Pellucid is to develop an adaptable platform for assisting organizationally mobile employees, in effect to re-engineer their work in the organization. This will improve organization effectiveness and efficiency by formalization, recording, storage and preservation of experience and knowledge; and support workers during integration in a new department or role by giving access to specific knowledge and experience accumulated in the past. At the technical level, the objective is to develop and integrate several advanced technologies in a customizable agent-based architecture. These technologies include autonomous cooperating agents; responsive interaction with the end-users; organizational memory; workflow and process modeling; and metadata for accessing document repositories. The objective is also to obtain experience with customization and to formulate guidelines for the best practice in using the Pellucid platform in assistance of organizationally mobile workers [1].

The main aim of the Pellucid System is to capture, record and capitalize the knowledge of current employees about their work in the organization. The stored data are successively analyzed and searched for knowledge and correlations between the used data and activities in working processes, in which the employee is taking part. The discovery of knowledge is performed by various means of data mining techniques as well as agent reasoning methodologies. Recent software for administration based processes such as Workflow Management Systems or Document Management Systems help users to automate their work, but these systems are not able to store users knowledge or discover hidden knowledge in organization. This is the domain, which Pellucid would like to address.

In order to track the work of employees, a system needs to know what are the activities or sequences of activities carried out during the work process by individual employees. Such process in which one or more activities are linked to realize together a business objective inside an organizational structure, is also called a business process and is identified within a process definition. The automation of a business process in whole or part is called Workflow [2, 3]. Pellucid uses the decomposition of business tasks to smaller parts (activities) by referencing individual activities with data used in a certain activity; this enables reasoning about data and actions performed by users.

Pellucid uses so-called Intelligent Agents based on FIPA standards for intelligent knowledge management and data mining. Using of agents makes Pellucid component-based, more scalable and more customizable. Designing Pellucid system based on agents help us to focus on smaller tasks which are solved by single agent, and then together you can create very complex system.

Ability of using ontologies makes Pellucid easy to customize for different problem domains by simply changing domain ontology. Results of artificial intelligent research can be easier included into the project when using agents.

Pellucid uses typical semantic web technology – ontology-based knowledge management. Using Workflow Management System, knowledge related information can be better organized and accessed by domain ontologies.

For interaction with the user Pellucid uses web technologies based on Java, XML and XSLT.

Pellucid project was launched in March 2002 and is currently in the prototype stage.

2 Pellucid Agent Architecture

Pellucid was designed as an extension to existing WfMS/WfTS. Therefore it works only in conjunction with an existing WfMS or WfTS and thus the Workflow Management or Workflow Tracking System (WfMS/WfTS) is mandatory.

Pellucid architecture consists of three main elements (see Figure 1):

- Pellucid Agents (PA) – taking care of monitoring reasoning and interfacing;
- Organizational Memory (OM) – where the information is stored;
- Web Server (HTTPD) – integrates Pellucid with WfMS/WfTS through Web Interface.
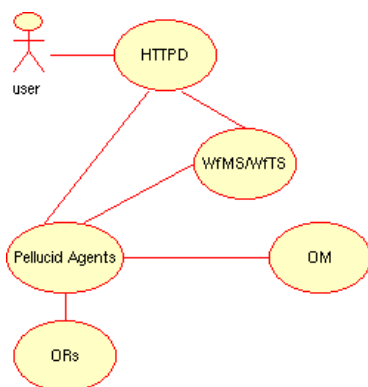
All the requests will be directed to a special Web Server. Web server will request the information from both the WfMS/WfTS and from Pellucid Personal Assistant Agents (PAAs). After the Web Server receives complete reply from the both systems it connects the two parts and creates the final Web output. The connection will be based on templates.

Workflow Management System (WfMS) reports about current workflow activities (process steps) to the monitoring agent, using Workflow Application Interface (WAPI). Pellucid Agents can also read process definitions from workflow through Monitoring agent and its interface to WfMS. WfMS holds its processes using Process Definition Language which is a part of WfMC standards.

Figure 1: UML scheme of Basic Architecture

Pellucid can integrate any Workflow system, which follows WfMC standards and has WWW Interface. Pellucid can be used also without WfMS in cases where there is no WfMS in the organization. However, there is a workflow in each organization, i.e. WfMS can be replaced by Workflow Tracking System (WfTS), which has less functionality than WfMS but current workflow user, performed workflow activity and time of this activity should be reported by WfTS to Pellucid System.

Pellucid is connected to Organizational Repositories (OR), where documents are stored.

2.1 Pellucid Modules

Generic version of Pellucid system has three modules:
- Intelligent Contact Management Module
- Intelligent Document Management Module
- Critical Time Management Module

List of contacts is presented in each organization in a form of contact database, searchable by keywords with sorting ability, etc. Intelligent Contact Management Module will provide users with intelligent contact list related to the activity, which is performed by user in contact relation to particular activity. There are organizational repositories available in each organization. Pellucid tries to relate documents to activity, which is performed by a user and this is a duty of Intelligent Document Management Module. Critical Time Management Module tries to extend WfMS/WfTS messages about deadlines and performance of workflow activities based on analysis of historical data from WfMS. Each module uses its ontology to define relations between knowledge entities such as activity, document, contact etc., and use common techniques to capture, capitalize and return knowledge to a user.

2.2 Organizational Memory

Organizational Memory (OM) holds the memory of the organization.
OM holds several types of data:
- Historical data - past process instances, users history, user feedback
- Organized knowledge data – created from historical data by Task Agents (TAs). TAs are providing data mining on historical data. Different ontologies are also included.
- Domain specific data - contact list, maps or other application specific data
- Agent Specific Data – include information such as local agent knowledge or larger amounts of data which are related to single agent.
- Metadata – information about data stored in Organizational Repositories (OR).

Every agent can manipulate with agent specific data stored in OM and also use OM ontologies. Several agents can write to and read from knowledge or historical data in OM. Organized Knowledge is created from historical data by classification of data by ontologies. Simple knowledge extraction is done by extracting ontology algorithms. Other suggestions and recommendations of Pellucid to the user are based on Agent Reasoning and Data mining techniques. Reasoning of Pellucid agents is very important part of Pellucid system. More information on reasoning in Pellucid can be found in [4, 5]

2.3 Pellucid Agents

In this section each Pellucid agent type is briefly described. Figure 2, Pellucid Agents UML Scheme, shows the types of agents and their interconnections. The scheme summarizes behaviors, the use of OM, events or abilities of an agent. Behaviors starts with "b", e.g. "bActivityTimeMng()" means behavior for activity critical time management. Events starts with "on", e.g. "onWfActivityStart()", which is activated when new activity is started in WfMS/WfTS.

Types of Pellucid agents:
- Role Agent (RA)
- Monitoring Agent (MA)
- Personal Assistant Agent (PAA)
- Task Agent (TA)
- Information and Search Agent (ISA)
- Capitalization Agent (CA)

Each role in workflow of organization is represented by RA per process instance and role. RA works (read, write) only with data from OM, which are relevant to the represented role. RA provides information to PAA about a ROLE, based on ACL requests from PAAs. Relevant information RA gathers directly from the OM or indirectly utilizing TA and ISA.
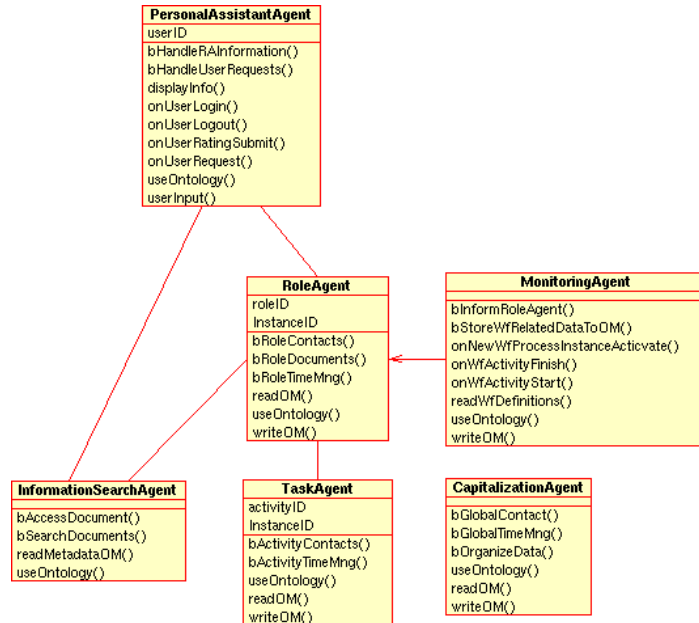
Figure 2: Pellucid Agents UML Scheme

RA serves to several PAA. RA is intelligent agent, which has knowledge about its role. RA will store its role knowledge in OM and supports reasoning [5].

Each user has its own Personal Assistant Agent (PAA). When the user logs into the system, PAA is activated and can serve to the user. PAA interacts with the user through HTTPD and Internet browser.

Information and Search Agent (ISA) is activated by RA to search for documents related to current activity. Relation criteria are considered by previous indexing of the documents. Indexing system does not create simple indexes of words but structural, ontology based indexing, where a title, author, text or creation time of document is known.

Task Agent is activated by RA to find knowledge related with certain activity in workflow. RA activates Task Agents to data mine information, which is not directly available by its role knowledge.

Capitalization Agent performs data mining on OM to find, organize and store global knowledge. CA is mainly data mining agent, it supports intelligent algorithms to reason about data and rebuild the OM.

2.4 Communication

Communication between Pellucid agents is based on FIPA Agent Communication Language (ACL). A message written in ACL is a structured message consisting of the following elements: **performative, sender, receiver, reply-to, content, language, encoding, ontology, protocol, conversation-id, reply-with, in-reply-to, reply-by;** for more details see [7, 8]. The most important elements (performative, content, language and ontology) are briefly described below. The remaining elements are simple elements, which control agent communication.

Here we give an example of Agent message used in Pellucid. Concrete Pellucid communication can be found at demonstrator website [6].

```
(query-ref
     :sender RA-4
     :receiver OM
     :content
     :language FIPA-KIF
     :ontology contacts-pellucid
          ((all ?c) (?c contact) (?a activity)
          (contactof ?a ?c) and (quality_of_reply ?c))
     ...)
```

Performatives

Each performative describes message types used in Pellucid. Pellucid will use only several performatives defined by FIPA ACL, namely INFORM, INFORM-REF, NOT-UNDERSTAND, QUERY-REF, REFUSE, REQUEST, FAILURE, REQUEST-WHEN, REQUEST-WHENEVER, SUBSCRIBE, AGREE

Content Languages

When Pellucid agents are communicating, they exchange some content – "text" of the message. Content can be written in different languages. Pellucid uses FIPA-KIF and FIPA-RDF language. KIF – Knowledge Interchange Format [10] is a language designed for use in the interchange of knowledge among disparate computer systems (created by different programmers, at different times, in different languages, and so forth). FIPA-KIF is FIPA's KIF specification for agent communication [9].

RDF – Resource Description Framework will be used in Pellucid as a content language in a FIPA message. The RDF model proposes the eXtensible Markup Language (XML) as an encoding syntax but does not prevent anyone from using alternative encoding schemes. All FIPA-RDF message contents will therefore use XML encoding, although, in principle, other encoding schemes could be used [11].

Ontology

Ontology in Pellucid defines the meaning of the terms in used content language and the relation between these terms. The model of agent communication in FIPA is based on the assumption that two agents wishing to converse, share a common ontology for the domain of discourse. It ensures that the agents ascribe the same meaning to the symbols used in the message. Using ontologies in Pellucid not only allows communication between agents but also gives a possibility for Pellucid agents to reason about the concept. Ontology is mostly represented by UML schemes, by objects, OKBC or by DAML+OIL [12] representation. One of evaluated MAS - JADE supports ontology definition [13, 14]. Several ontologies need to be created for Pellucid project, e.g. **Ontology of Organization**; **Ontology of Workflow Reported Data** and Domain specific or module specific ontologies such as **Contact Ontology** or **Traffic Light Ontology**.

4 Pilot Applications

There are three pilot applications in the Pellucid project. All three applications are dealing with public administration processes but in different areas. We consider that integrating

Pellucid into those three different applications will evaluate described architecture and will help us make the architecture general enough and valuable for assisting employees in public administration processes.

4.1 Administrative departments of the MMBG

The Mancomunidad de Municipios del Bajo Guadalquivir is an organization created by eleven local authorities with the main objective of contributing to the social and economic development of an area with 250,000 inhabitants. The particular problem of MMBG is the wide range of tasks that its employees must handle. They include managing of joint services (such as recycling, cultural projects), provision of innovation and technology services (such as identifying opportunities and weak points in the region), support to business initiatives, etc.

4.2 Call-center of the CPRE-JA

RCJA – Red Corporativa de la Junta de Andalucia is the Telecommunications Corporate Network of the buildings of the Junta de Andalucia with 50 departments and 1,250 buildings connected for Data services, 53 departments, 550 buildings, and 47,000 lines for fixed telephony services, 53 departments, 7,300 lines for mobile telephony services. A management and resolution of fixed telephony breakdowns by the agent of a call centre was chosen as a representative workflow process within the organization.

Figure 3: A process definition for a traffic light installation process. Designed in Ultimus Process Designer

4.3 MTD in Genova

The pilot application of the Comune di Genova will address the support to an organizational mobility among the several areas of the Traffic and Mobility Management Department of a large city administration - the department managing facilities and technical systems belonging to the urban and near-urban road system. A process of new traffic light installation was modeled by Ultimus Process designer (see Figure 3) in order to demonstrate some possibilities to improve the process a cooperate with the Pellucid platform.
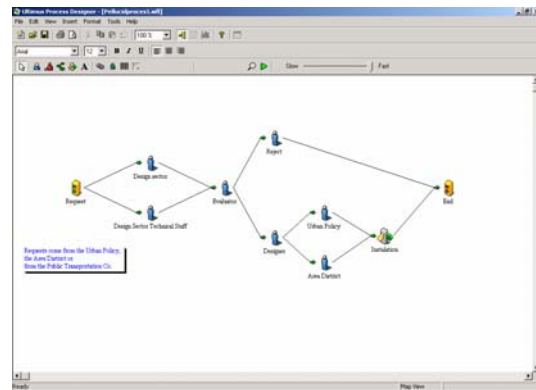
4 Pre-prototype Demonstrator

Pellucid project was launched in March 2002 and currently it is in the prototype stage. The pre-prototype demonstrator was already created. It is a simulation of the behavior of the Pellucid system. It is based on the pilot applications of Comune di Genova, Mobility and Transport Department: process for planning, installation and maintenance of traffic lights, with the purpose to illustrate the basis for knowledge management system.

The demonstrator is not implemented by use of the tools, which will be used for the real system development (except for the web interface). It concentrates on behavior rather than implementation details (which are considered independently). The demonstrator can be found

on the Pellucid website of the Institute of Informatics [6] http://pellucid.ui.sav.sk/demonstrator/.

Pellucid team evaluated recent Multi-Agent Systems [15]. JADE [17] and Grasshopper [16] agent system were recommended for real development of Pellucid System.

Pellucid demonstrator concentrates on the agent system behaviors. Its screen structure is divided into three parts (Figure 4):

- Data flow demonstration among agents, webserver, workflow management/tracking system, organizational memory and (external) organizational repositories.
- Examples of communication messages in XML according to current state of the data flow.
- Control buttons and current state indicator.

Flow of Data between Agents Demonstration of the Pellucid Agent System in cooperation with Workflow Management / Tracking System.	Communication messages (in XML) according to demonstrator's current state
Control buttons	Current state indicator	

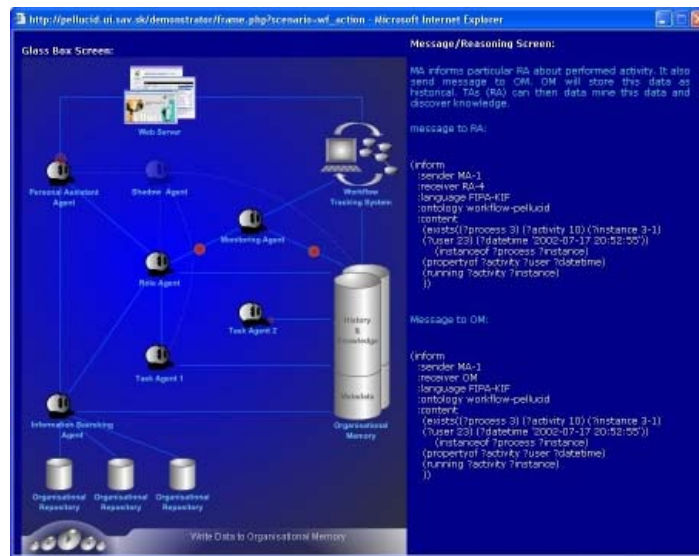Figure 4: Screen structure of Pellucid demonstrator

Figure 5: Screenshot of Pelucid Demonstrator.

4 Conclusion

In this paper we describe briefly the Pellucid Agent architecture, to be applicable in any organization with administrative processes. Pellucid extends the abilities of Workflow Management System and makes it more intelligent. Pellucid assists employees by recommendations and suggestions that help them at their current work activity. Pellucid captures employee's work and requires only minimal input from the user. The demonstrator explains how Pellucid works in a concrete application. Pellucid benefits from using agent technology, which makes the system more customizable and modular. Agents also allow easy integration of intelligent techniques of knowledge management, knowledge extraction and data mining.

Acknowledgements

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