AGENCY FOR INTEGRATION, DIFFUSION AND ARCHIVE OF MEDICAL INFORMATION

by

António Abelha
Departamento de Informática, Universidade do Minho, Braga, Portugal
abelha@di.uminho.pt

Abstract

Information sources in a healthcare unit are distributed, heterogeneous, large and complex; integrate medical equipments that speak different languages; are built around information systems customized by several companies using different operating systems, languages, applications and hardware. Communications are sometimes limited by old infrastructures and new projects collide with financial restrictions and bureaucratic delays. The homogeneity of clinical, medical and administrative systems is not possible due to financial and technical restrictions, as well as functional needs. The solution is to integrate, diffuse and archive this information under a dynamic framework, in order to share this knowledge with every information system that needs it. In this paper, it is presented AIDA – Agency for Integration, diffusion and Archive of Medical Information. AIDA is an agency that supplies intelligent electronic workers called pro-active agents, in charge of some tasks, such as communicating with the heterogeneous systems, sending and receiving information (e.g., medical or clinical reports, images, collections of data, prescriptions), managing and saving the information and answering to information requests. AIDA also supports Web based services to facilitate the direct access to the information and communication with human beings.

Keywords: Artificial Intelligence, Intelligent Agents, Medical Information systems.

1. Introduction

AIDA is an agency or a Multi-Agent System (MAS). Its construction follows the acceptance of simplicity, the conference of the achievement of common goals and the addressing of responsibilities. The main goals are to integrate, diffuse and archive large sets of information from heterogeneous sources (departments, services, units, computers, medical equipments). AIDA also provides tools in order to implement communication with human agents based on web based services. Under these presuppositions, a Hospital Information System (HIS) will be addressed in terms of:

- The Administrative Information System (AIS), which intends to represent, manage and archive the administrative information during the episode (an episode is a collection of all the operations assigned to the patient since the beginning of the treatment until the end);
- The Medical Support Information System (MIS), which intends to represent, manage and archive the clinical information during the episode;
- The Nursing Support Information System (NIS), which intends to represent, manage and archive the nursing information during the episode;
- The Electronic Clinical Process Information System (ECP);
- The Information Systems (DIS) of all the departments or services, in particular of the laboratories (Labs) and Medical Imaging (MI).

In this paper, we will look to the integration, diffusion and archive of information from clinical laboratories and medical imaging equipments.

2. Multi-agent systems

MAS set a new paradigm in problem-solving via theorem proving; i.e., agent-based computing has been hailed as a significant break-through in problem solving and/or a new revolution in software development and analysis. Indeed, agents are the focus of intense interest on many sub-fields of *Computer Science*, being used in a wide variety of applications, ranging from small systems to large, open, complex and critical ones [3][4]; i.e., agents are not only a very promising technology, but are emerging as a new way of thinking, a conceptual paradigm for analyzing problems and for designing systems, for dealing with complexity, distribution and interactivity. It is, may be, a new form of computing and intelligence.

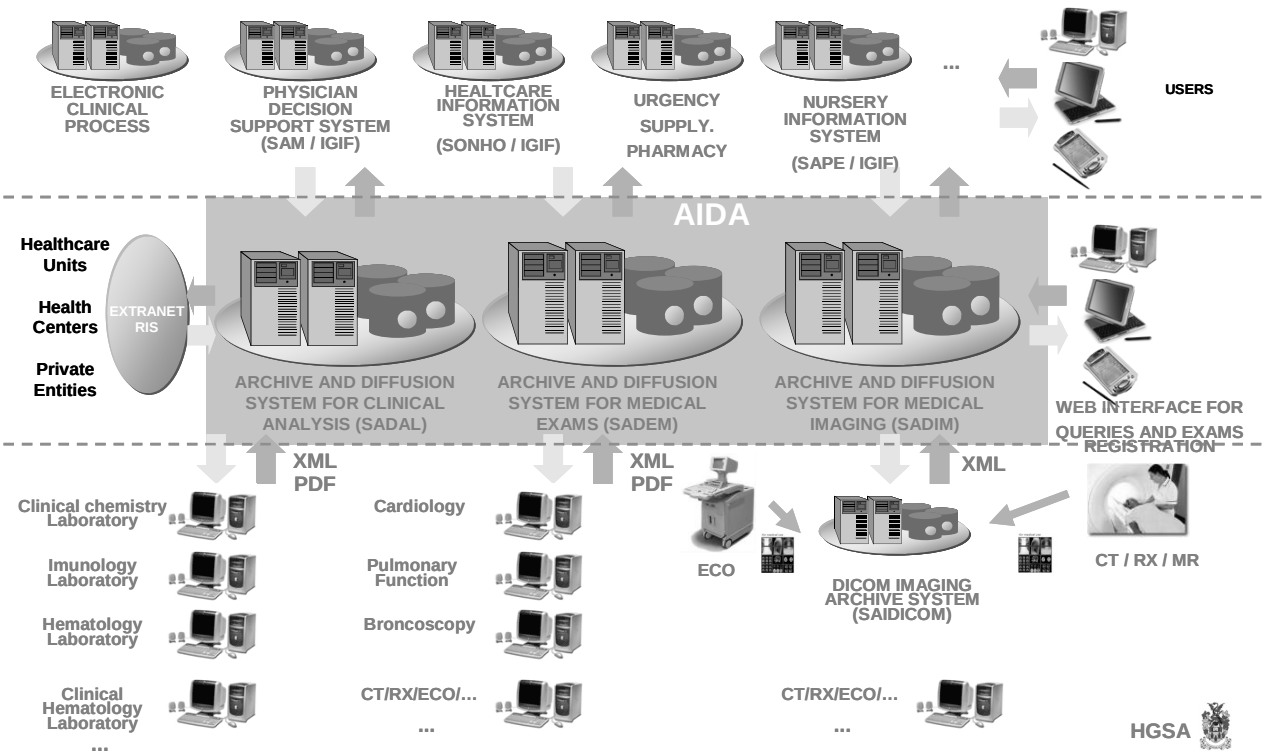

Figure 1 – AIDA Architecture

Although there is no universally accepted definition of *agent*, in this work such an entity is to be understood as a computing artifact, being it a hardware or software entity, which exhibits the properties:

- *autonomy*; i.e., whereby such entities have the ability to act without the direct intervention of their peers, namely humans;
- *reactivity*; i.e., whereby such entities are situated in an environment that they can perceive through sensors and act in reaction to stimuli (e.g., revising their beliefs according to or in reaction to new inputs);
- *pro-activity*; i.e., whereby such entities exhibit intelligent problem solving capabilities (e.g., planning their activities in order to achieve short or long term goals); and
- *social behaviour*; i.e., whereby such entities are *aware* of one another, can *interact* with one another and may *modify* their behaviour in response to others; can *communicate* via a set of low or high level constructs and protocols as well as means of addressing and direct communication; can *cooperate* in order to achieve joint as well as individual goals, what means that they must have the ability to negotiate with other agents either to accomplish their own goals or to joint plans to achieve common goals; to perform *belief revision* in the context of additional sources of information provided by their peers.

These systems have provided clear means of monitoring the agent's behavior with significant impact in their process of knowledge acquisition and validation. This type of model will be now applied in the development of a computational architecture that will support *Medical Assistance* on the area of Electronic Clinical Process. The acquisition of the knowledge required to construct these systems involved the familiarization with some medical equipments and procedure documentation, as well as the regular participation of the authors in operational sessions at the premises of the health care units, just to name a few.

3. Agent-Oriented Medical Systems

AIDA is then envisaged to support the medical applications, a form of a web spider of intelligent information processing system, its major subsystems, their functional roles, and the flow of information and control among them, with adjustable autonomy. Indeed, many complex systems are made up of specialized subsystems which are understood as intelligent entities or agents that interact in flexible, goal-directed manners, and are understood as theories [5]; i.e., the intelligence of such a system as a whole arises from the interactions among all the system's entities. AIDA is therefore a

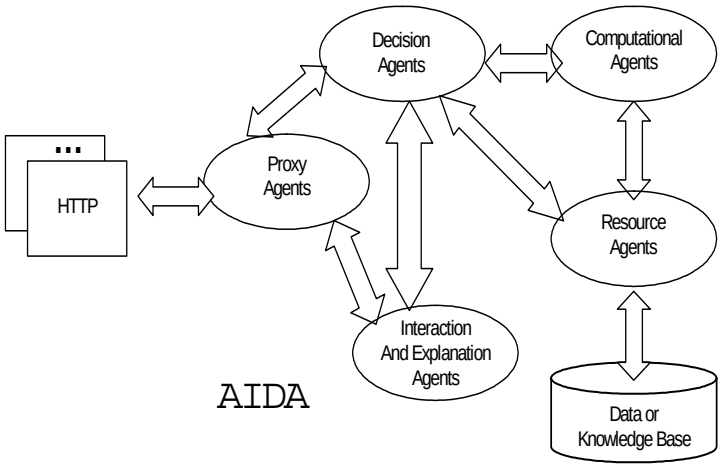

Figure 2 – AIDA agents

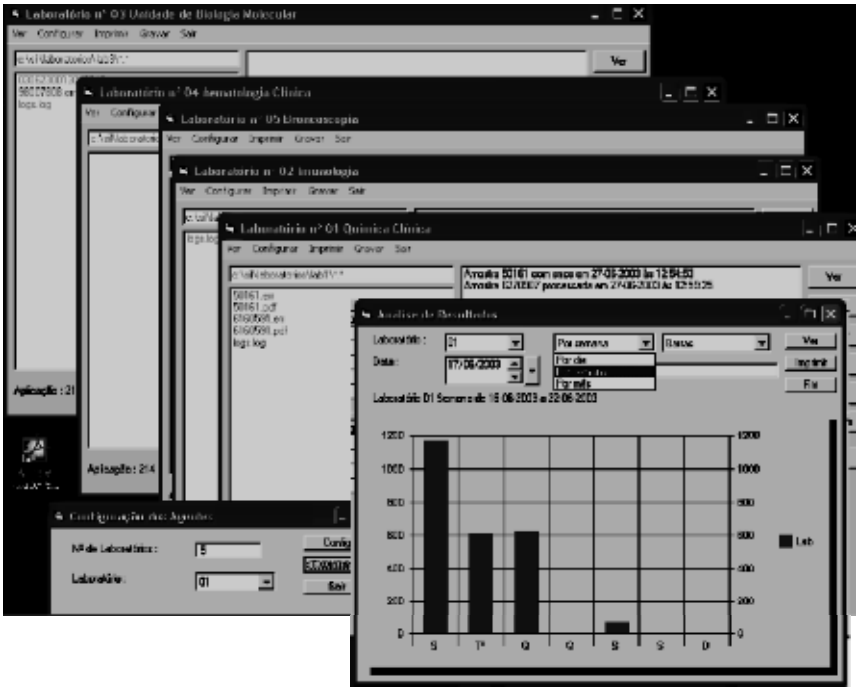

Figure 3 – Agent Monitoring

purely communicative *Multi-Agent System* (*MAS*); i.e., there is no external environment influence and the agents communicate only through messages. The general architecture of AIDA is given in Figure 1 and Figure 2, being a brief description of the different types of agents involved given below, in terms of:

- The *Proxy Agents* (*PAs*) which provide the bridges between the users and the system in terms of questions that may be formulated, explanations that may be required, decisions that may have to be taken and/or view of final results. The system's interfaces are based on Web-related front-ends using Hypermedia pages, that can be accessed using a standard Web browser;
- The *Decision Agents* (*DAs*) which present mediating capabilities, act by accepting a task from the *PAs*. They may decompose it in sub-tasks, sending them to be processed in the *CAs*, integrating later the results (returned by the *CAs*);
- The *Computing Agents* (*CAs*) which accept requests for specific tasks from the *DAs*, returning the results;
- The Resource Agents (*RAs*) which present all the necessary knowledge to access a specific data resource; and

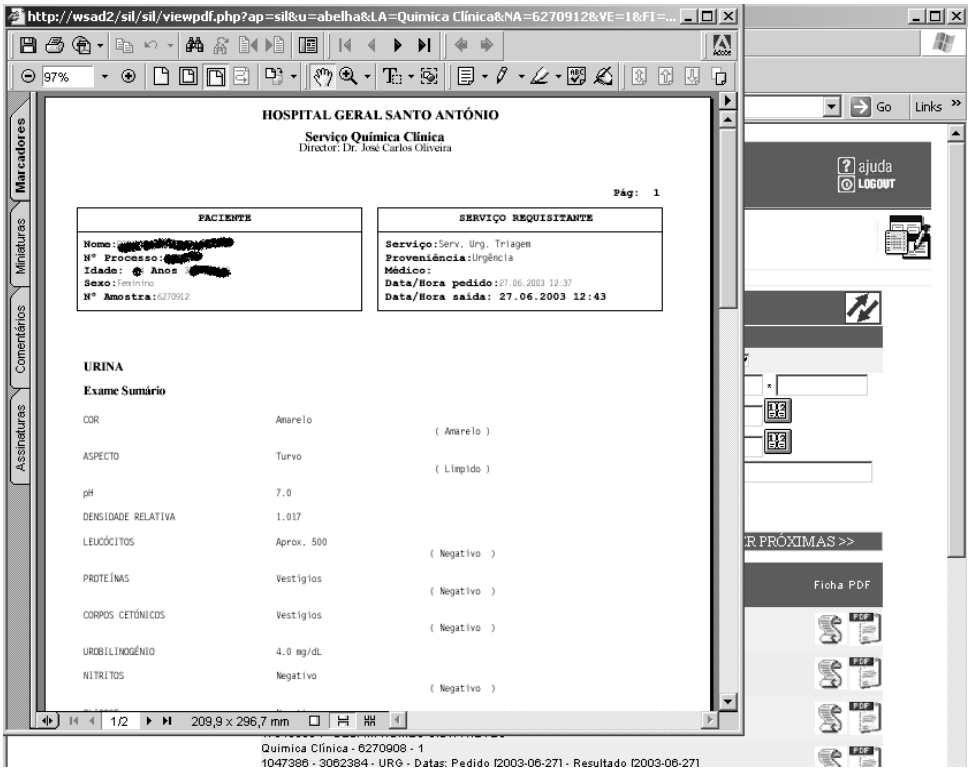

Figure 4 – HIS Web tools

- The *Interaction and Explanation Agents* (*IEAs*) which act based on argumentative proceedings which are fed with data and/or knowledge coming either from the *PAs* or the *DAs*. Note that the execution plans received from the *DAs* may be partial, so that only upon a completion of a task a trace can be compiled and an explanation can be delivered to the *PAs* and/or *DAs*.

4. A Computational Environment for AIDA

In order to implement this system, distributed by nature, Internet technology was used on the side of the end user. The system is user-friendly, Web based, of low cost, uses freeware tools or software database packages which licenses belong to the Portuguese Health Ministry (e.g., Oracle software). The intranet was implemented using a *PC* with *LINUX* as operating system and an ORACLE RDBMS, a PC with Windows with Internet Information Server, and a network of PCs with Linux for storing images, videos or clinical reports. Outside connections were achieved via an *ISDN* router with *RAS* (*Remote Access Service*) [1][2].

When building AIDA, it was taken for granted that agents which make up the system will need to communicate. Communication among agents will be performed in a 4-step process via:

- defining the transportation (i.e., the process that allows for a message be sent or received);
- defining the language (i.e., the meanings of a message);
- defining the ontology (i.e., the conversational structure);
- defining the architecture (i.e., the system linking according to protocols).

A message is sent by an agent putting an XML file in a shared directory. Shared directories are created by administrators using operating systems commands on a samba-like server. The sharing is only allowed for agents that know the password. Immediately, the file is processed by the receiver. According to the ontology the message is processed, integrated and archived in databases. The ontology is defined by the administrators and can be managed using web tools. Two examples are shown in a paper's appendix. The health care network is used for physical transportation. The agent monitoring is presented in Figure 3. An example of the HIS Web tools is shown in Figure 4.

5. Future Work

The next step concerns with the creation of specific agents in order to integrate information from other sources. The project includes the diffusion, integration and archive of information of the health care intensive care unit departments. This information is retrieved and processed from medical equipments and is sent to AIDA.

6. Conclusions

Much work has therefore been concentrated on developing problem solving methods and building strategies for such systems that may mitigate faults in health care environment. The overall trend has been

away from seeing the process as one of encoding heuristics derived from an expert, towards modelling the domain on which the expertise operates. Further, it has become recognized that modeling requires as a precondition that the domain be conceptualized, and that it is paramount that the assumptions incorporated in the conceptualization must be made explicit. Furthermore, a protocol based in XML syntax allows for information sharing and its consequent interpretation.

The system is now at work at the *Hospital Geral de Santo António*, in *Oporto*, one of the two major health care facilities in the north of Portugal. It is expected that under the *Interreg III* programme, an *European Commission* initiative, it will spread across the health care facilities in the north of *Portugal*, as well as in *Galiza* and *Castela and Leão* in *Spain*.

References

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APPENDIX

Example 1: XML message sent by the Computer Tomography Agent

```
<?xml version="1.0" encoding="ISO-8859-1" standalone="yes" ?>
<study>
<studyuid>
1.2.840.113619.2.22.288.1.14889.20030603.281832
</studyuid>
 <studydate>03062003</studydate>
 <patientid>INT3003115</patientid>
 <patientname>
OSVALDO AMBROSIO
</patientname>
 <module>INT</module>
 <episode>3003115</episode>
 </study>
```

Example 2: XML message sent by the Laboratory Information System Agent

```
<?xml version="1.0" encoding="ISO-8859-1"
standalone="yes" ?>
<exam>
<number> 3100914 </number>
<process> 735890 </process>
<episode> 3002081 </episode>
<module> INT </module>
<requestdate> 10-03-2003 </requestdate>
<requesttime> 11:45 </requesttime>
<examdate> 10-03-2003 </examdate>
<examtime> 16:17 </examtime>
<codservice> lab01 </codservice>
<user> SILVA </user>
<type > I </type>
<name> ERNESTINA SILVA SANTOS </name>
<sex> 1 </sex>
<borndate> 01-12-1923 </borndate>
<service> Nefrologia </service>
<origin> Consulta Externa </origin>
<physician> Luisa Lopes Lama </physician>
<report> <group>
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<subgroup>
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<analyse> <designation> COR </designation>
<value> yellow </value> <unit> 0 </unit>
<limit> yellow </limit>  </analyse>
<analyse> ...  </analyse>
...
</subgroup>
...
</group> </report>
<admcodes>
<code> A22954 </code> <code> A22957 </code>
...
</admcodes>
</exam>
```