Agents in PIPS Project: the Usage Scenario and the Feasibility Study

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Abstract. This paper presents the usage scenario developed for the PIPS Project to demonstrate the employment of the agent technology. Within the scenario agents represent each actor involved in the PIPS value chain. Five phases of the scenario illustrate different roles and functions of the agents. The scenario also served as a basis for a feasibility study for the PIPS. The second phase of the scenario was successfully implemented. Short time and facility of the development may encourage using the agent technology in the PIPS Project.

1 Introduction

The agent technology is the answer for the current trend of development of large-scale distributed, highly dynamical environments integrating existing legacy systems and consisting of diverse components [9]. The agent technology facilitates the system design since desired system functionalities may be simply projected onto agents. Moreover, according to Luck et al [9], agents improve system deployment and provide faster return of investment. They advance large-scale distributed or decentralized system integration with highly adaptive and dynamic business logic, fit step-by-step system integration and facilitate coalition formation. Agents allow a broad range of users to access a broad range of services offered by different frequently competing organizations [4]. Additionally agents present a number of technological advantages including: bandwidth conservation, faster task completion, latency reduction, disconnected operation, load balancing and dynamic deployment [6].
On the other hand the agent technology imposes a number of drawbacks to overcome which a number of initiatives were introduced. First, the mobile agent technology introduces significantly new threats [4] which relate to agent's mobility. However they are the concern of research of various scientific groups and a number of solutions have been proposed there are still problems not resolved completely. Second, the agent technology suffers from the lack of mature software development method-

ologies for agent-based systems. Basic principles of software and knowledge engineering need to be applied to the development and deployment of multi-agent systems [9]. Another problem is agent platforms immaturity. Although there are several relatively mature, development-oriented platforms and some richer, more research-oriented agent platforms, most platforms are still too immature for operational environments [9]. Agent technology is a relatively recent technology what among the others effects in a lack of awareness of the potential applications of agent systems [9] what may prevent system developers from applying the agent technology to their solutions. The recentness of the technology influences also the cost of system development and implementation, both in direct financial terms and in terms of required skills and timescales. As agent design tools and standard methodologies are developed, and as development teams gain greater experience, these costs should fall [9].
Since the PIPS matches the description of large-scale distributed, highly dynamical environment integrating existing legacy systems and consisting of diverse components [10] which development, as mentioned above, may profit from using the agent technology, it is worth considering the employment of agent technology in the PIPS Project.
To extend the briefly summarized literature study of pros and cons of the agent technology with practical examinations, the author developed usage scenario illustrating the position of the agent technology in PIPS system. Five phases of the scenario demonstrate different roles and functions of the agents. The scenario consists of a PIPS customer (Mary) who interacts with the PIPS system in different contexts. The PIPS system itself consists of different types of services and actors. Within the system actors are represented by agents, in most cases called 'virtual egos'. Mary suffers from a chronic heart disease and therefore needs semi-continuous medical care and needs to take care of her diet.

2 Phase 1: In the airport

2.1 Remote health data uploading and GP advise

Upon arrival in the airport of Zurich, Mary starts to feel unwell.
She goes to the lounge and decides to call her General Practitioner (GP) for advice on the mobile phone. Mary, aware of her health risk, always carries her personal device for monitoring vital health signs. This device can be worn on her wrist similarly to ordinary wristwatch. Upon activation by her, it measures and stores various physiological parameters such as heart rate, heart rhythm regularity, respiration rate, body temperature, SPO2 and ECG.
The GP asks her to send the recent batch of measurements to the PIPS system, where her electronic health record is located. Mary decides to use the wireless (WLAN) network in Zurich airport to connect to the Internet and to upload her health data to the PIPS system. She gets an access token from the WLAN service provider and connects her notebook to the Internet via a hotspot. After having transferred the data from her vital sign monitor to her notebook by a Bluetooth connection, she opens a

secure connection to the PIPS system and starts uploading the data to her health record.

The GP looks into the results of monitoring, reads Mary's health history and requests his Virtual Ego (VE) to prepare a list of illnesses matching Mary's symptoms. The VE contacts a PIPS Knowledge Discovery Agent (KDA) which starts to search in PIPS Knowledge Base. The KDA also communicates with Information Agents to get access to knowledge stored outside the PIPS system. After gathering all data, the GP VE selects the most significant information and presents it to the GP. Supported by the list, GP recognizes Mary's disease and sends Mary a therapeutic plan by email, including prescription for medicines and nutritional advices.

2.2 Agents' Functions

Mary's Virtual Ego:

- transfers the medical results taken from Mary's Medical Device to the Mary's Electronic Health Record (EHR)

General Practitioner's Virtual Ego:

- presents the requested data from Mary's EHR to the GP
- supports the GP during formulating the medical and nutritional advice for Mary, by presenting the diseases matching Mary's symptoms and providing additional nutritional knowledge (interoperates with the KDA to achieve the list of diseases matching the symptoms, interoperates with the KDA to obtain additional nutritional information, prepares the most significant results and shows them to General Practitioner)

Knowledge Discovery Agents (from the PIPS Description of Work [10]):

- receive a demand from the virtual egos and resolve the complementary requirements needed for generating a practical result, asking such data to the adequate virtual information agents and virtual egos

(Virtual) Information Agents (from the PIPS Description of Work [10]):

- represent the data sources regarding the scientific knowledge and the food knowledge, which are general and not directly linked to the actors participating in the processes of the chain
- provide information to all the other agents, following their demands in order to include in the environment these information categories

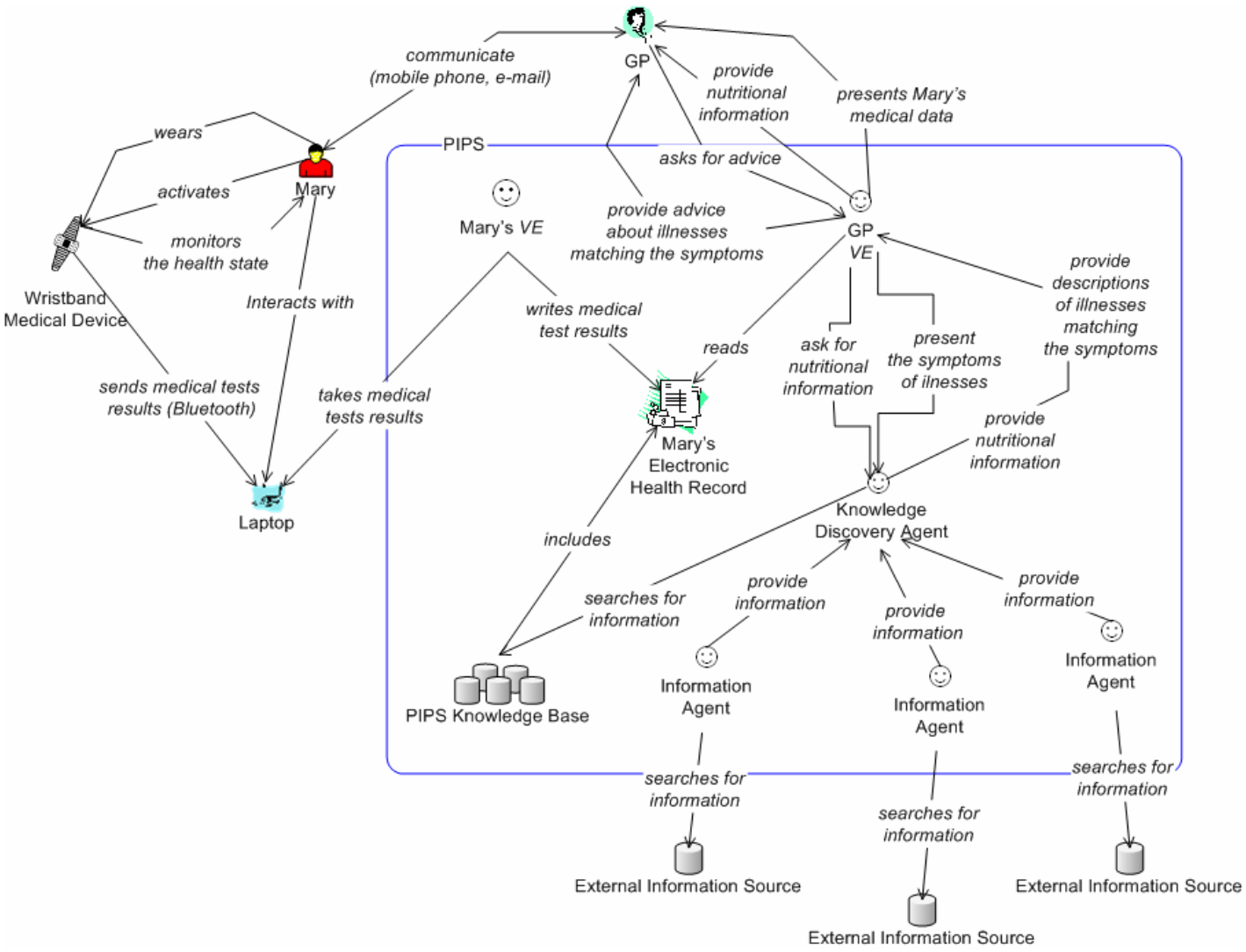

Fig. 1. Illustration of actors, agents and assets and interactions between them in PIPS Usage Scenario Phase 1: In the airport.

3 Phase 2: At home

3.1 PIPS (virtual) medical advise

After five days Mary is still unhealthy and she decides to log in the PIPS system.
The PIPS GP VE goes with her thru a brief questions/answer session. Afterwards, she is asked to upload a recent batch of health data and she does it. After analysing them, the GP VE advises Mary to see a specialist doctor.

3.2 Planning for a specialist doctor

Mary still connected to the PIPS system, requests her VE to arrange the appointment for between three and five in the afternoon. She describes her preferences. Mary's VE looks into the PIPS Directory Facilitator (DF) – the place where all agents register their services - and prepares the list of SD VE to contact and negotiate the visit. It also communicates with KDA to receive patients' opinions about the doctors.
After contacting the Egos, Mary's VE presents Mary a short list of specialist doctors situated in the area close to her home and satisfying her preferences. The list includes characteristics of doctors accompanied with patients' recommendations.
Mary selects the one who expects a reasonable price for a visit and has good opinion between other patients. The appointed is agreed. The SD VE notifies the SD about this.

3.3 Agents' Functions

Mary's Virtual Ego:
- mediates between Mary and General Practitioner Virtual Ego during a medical interview
- transfers the medical results taken from Medical Device to the Mary's EHR
- arranges the visit to a GP (gets Mary's preferences, looks into the DF for available specialist doctors, interoperates with KDA to obtain additional knowledge about the specialist doctors, contact the SD VE and negotiates the conditions of the visit, prepares a list with most adequate doctors, contacts the SD VE to confirm the visit)

General Practitioner's VE:
- conducts the medical interview with Mary (formulates the questions, analyses Mary's answers)
- formulates medical advice to Mary (reads Mary's EHR, interoperates with KDA for additional knowledge and makes autonomous decision concerning steps to be taken in Mary's case according to the knowledge)

Specialist Doctors' Virtual Egos:

- register specialist doctors in PIPS Directory Facilitator (showing the doctors availability, the range of their services etc)
- arrange the meetings with patients (negotiate the conditions of the visits with patients' VE, notify Specialist Doctors about arranged visits)

Knowledge Discovery Agents and (Virtual) Information Agents: as above.

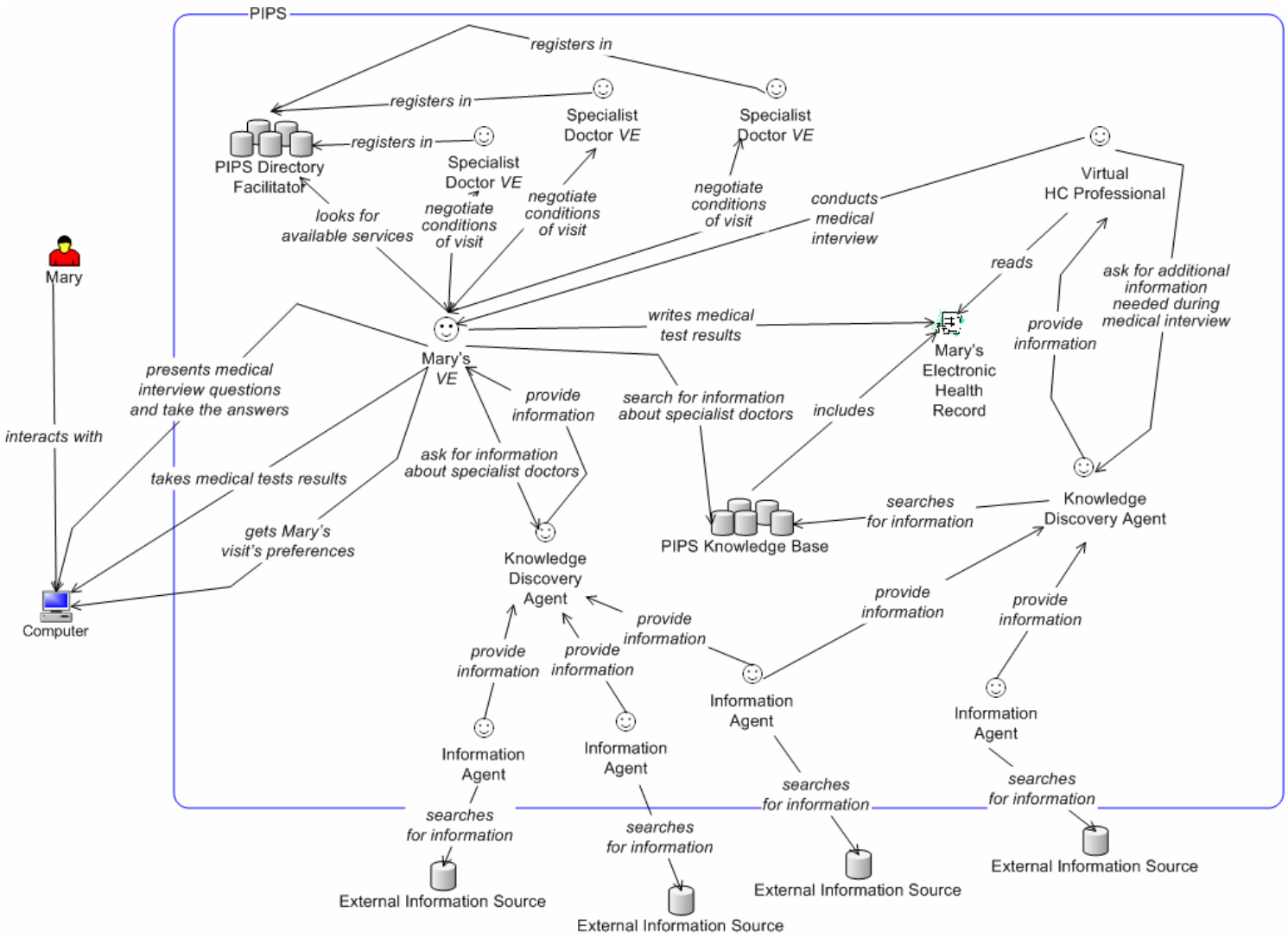

Fig. 2. Illustration of actors, agents and assets and interactions between them in PIPS Usage Scenario Phase 2: At home.

4 Phase 3: At healthcare centre

4.1 PIPS supported Lab test and therapy prescription

Using his PC, the specialist doctor looks into Mary's monitoring results from past weeks and decides to direct Mary for additional tests. He requests his VE to arrange the laboratory tests for Mary in the local laboratory, but unfortunately, the local laboratory is very busy in this time.

To have the tests done faster, Mary and doctor decide to conduct them in another laboratory. The doctor requests his VE and after a while is presented with a list of alternative laboratories. He selects the closest one. As soon as the visit is accepted the laboratory professionals are notified about this by their VE.

Mary goes to the laboratory. The tests are conducted and Laboratory Professional's VE stores the results in Mary's electronic health record. The SD is instantly informed when the results are ready. He examines them and prepares a therapy. The SD VE sends the therapy to Mary's VE which presents it at the Mary's PDA. Since Mary's VE checked before the availability of the prescribed medicines in Mary's home, it accompanies the therapy with the additional message that some of medicines Mary are unavailable. Mary decides to pass at the pharmacy on her way back home.

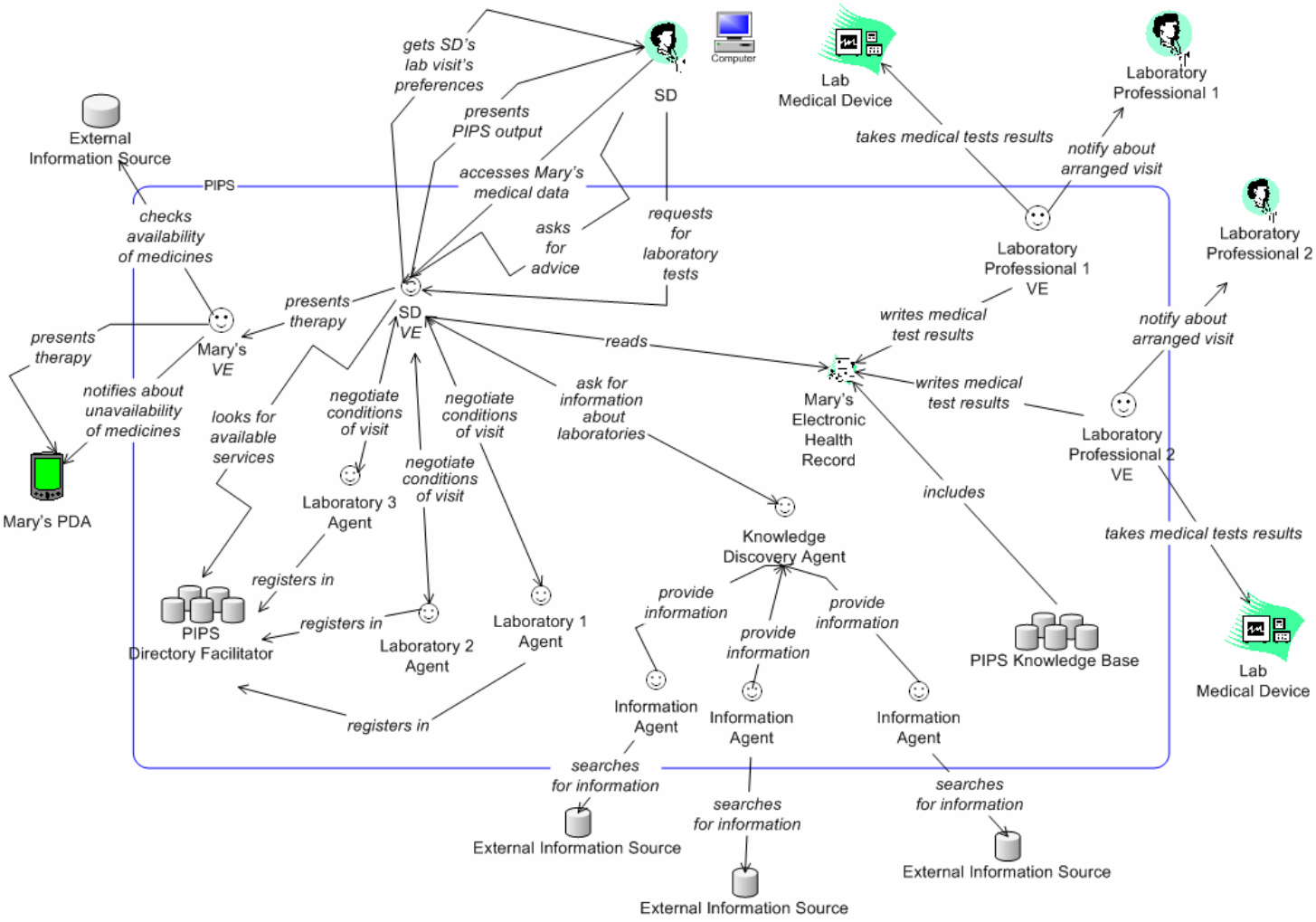

Fig. 3. Illustration of actors, agents and assets and interactions between them in PIPS Usage Scenario Phase 3: At healthcare centre. The connectors symbolizing the communication between Laboratory Agents and Laboratory Professionals' Virtual Egos (see par. 4.2) were omitted to prevent clearance of the illustration.

4.2 Agents' functions

Mary's Virtual Ego:

- accesses information about medicines which Mary has at home, checks if medicines needed are available when a therapy is prescribed and notifies Mary when they are not
- mediates between Mary and SD VE during a therapy presentation

Specialist Doctor Virtual Ego:

- arranges the visit to a laboratory (gets SD preferences, looks into the DF for available laboratories, interoperates with KDA to obtain additional knowledge about the laboratories, contact the Laboratory Agents (LA) and negotiates the conditions of the visit, prepares a list with most adequate laboratories, contacts the LA to confirm the visit)
- supports SD during the Mary's therapy preparation (reads Mary's tests' results in Electronic Health Record, interoperates with Knowledge Discovery Agent for additional knowledge and presents this data to the SD)
- mediates between SD and Mary's VE during a therapy presentation

Laboratory Agent:

- registers the laboratory in PIPS DF (showing its availability, the range of services etc)
- arrange the laboratory visits of patients (negotiate the conditions of the visits with SD VE, notify Laboratory Professionals' Virtual Egos about arranged visits)

Laboratory Professionals' Virtual Ego:

- transfers the medical results from Medical Device to the Mary's Electronic Health Record (EHR)
- notify Laboratory Professionals about arranged laboratory visits

Knowledge Discovery Agents and (Virtual) Information Agents: as above.

5 Phase 4: At pharmacy

5.1 Remote access to medicine prescription

When Mary arrives at the pharmacy she just tells her name to a pharmacist. He types it into his computer and got the list of needed medicines. The list was prepared earlier when Mary's VE contacted the Pharmacy Agent and checked if the medicines are available in the pharmacy. She buys them and leaves the pharmacy.

5.2 Agents' functions

Mary's Virtual Ego:

- accesses information about medicines which Mary has at home and arranges the eventual replenishments with Pharmacy Agents

Pharmacy Agent:

- registers the pharmacy in PIPS DF (showing its availability, the range of services etc)
- publishes the information about availability of medicines (and other pharmacy's specific information e.g. open hours, address)

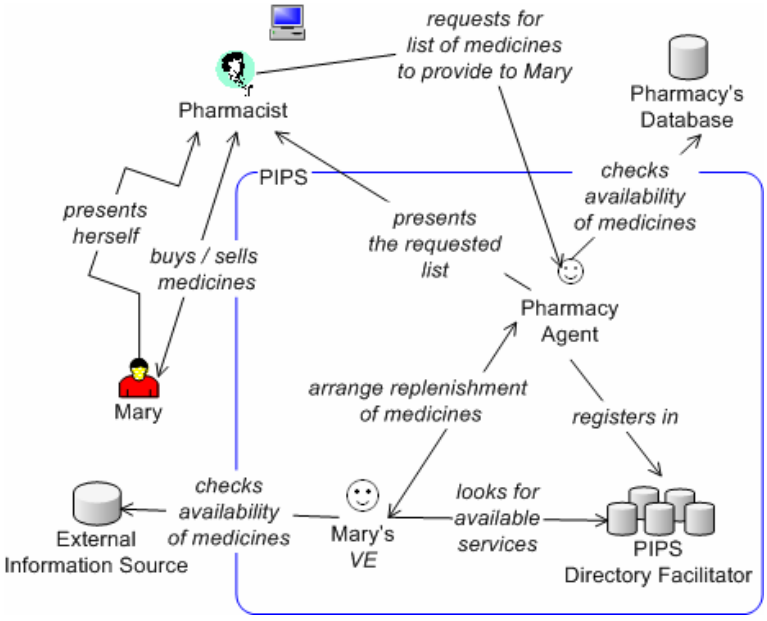

Fig. 4. Illustration of actors, agents and assets and interactions between them in PIPS Usage Scenario Phase 4: At pharmacy.

6 Phase 5: In supermarket

6.1 Remote PIPS supported nutrition advise

Mary goes to the supermarket. She passes to a PIPS kiosk and logs on to her private health space. Using an RFID (provided at the supermarket), she scans the codes of some food products providing the products' identifiers to her VE. Mary's VE looks for comprehensive information about the products. It also matches them with Mary's

health profile and her preferences and advises about the appropriateness of these products.

6.2 Agents' functions

Mary's Virtual Ego:

- supports Mary with advice about the food products (takes the identifiers of RFID scanned food products from the supermarket computer system and interoperates with Knowledge Discovery Agent to gather more knowledge about the products, accesses Mary's health profile, formulates nutritional advices according to the knowledge and to Mary's preferences)

Knowledge Discovery Agents and (Virtual) Information Agents: as above.

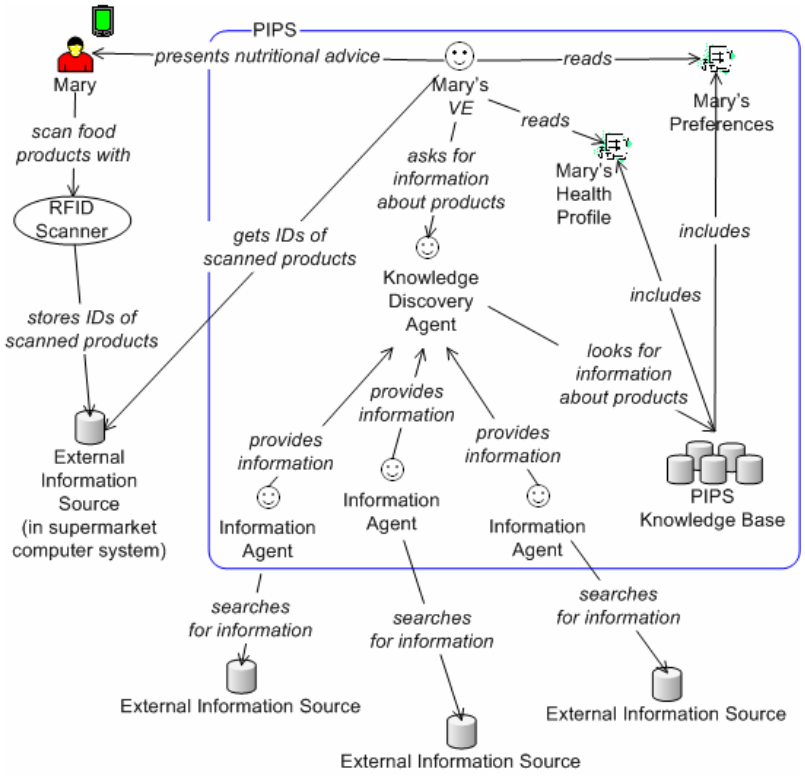

Fig. 5. Illustration of actors, agents and assets and interactions between them in PIPS Usage Scenario Phase 5: In supermarket.

7 Feasibility study

The second phase of this scenario was implemented in Java Agent Development Framework (JADE). The JADE was selected from the 11 platforms conforming FIPA specifications because of numerous advantages. It is publicly, freely available under the conditions of Lesser General Public License (LGPL) and very popular, the hosts of JADE site noted about 40 000 downloads of the platform. Since the PIPS project foresees the use of mobile devices it is important to have a light-weighted release of the platform. For JADE such distribution exists - the JADE Lightweight Extensible Agent Platform (LEAP) [8]. JADE is continuously developed, improved and maintained, not only by the developers from the Telecom Italia Lab (Tilab), where it was originated, but also by contributing JADE community members. JADE also supports the development of ontologies used to represent agents' knowledge. The ontologies can be designed using Protégé [11] and then converted into JADE compatible Java classes using JadeJessProtege (plugin for Protégé) [3]. JADE is also conveniently accessible. The developers and users can download not only the current version of JADE (Jade 3.1 - 17/12/2003) but also the recent snapshots encompassing latest improvements of the environment [7].
The overall development of the feasibility study application, including design and implementation took ten person/days which is relatively short considering the fact that it also included the learning phase. JADE is very well documented, developers may get familiar with it very quickly. The authors of the documentation respect to the pay as you go philosophy, meaning that the programmers do not need to use all the features provided by the middleware and the features that are not used do not require programmers to know anything about them [1]. The employment of the agent technology introduced a very comfort in designing and implementing of the environment. The design of agents relied simply on incorporating into them the identified agents' functions and designing the communication protocols. The FIPA Specifications (which, as mentioned above, are implemented in JADE) predefine different interaction protocols (e.g. for querying, requesting, brokering, recruiting etc [5]) so in many cases the design of communication reduces to choosing the proper one. With once designed agent it is very easy to proliferate it and deploy allover the distributed environment. JADE provides very friendly graphical interface which allow managing the different components of the environment. For example the JADE administrator can control the lifecycle of agents and containers. It is also possible to watch the internal state of the environment in the meaning of sent and received messages, registered services and state of components [2].

8 Conclusions

The agent technology presents a number of advantages, most of them relating to business benefits from improving development of large scale distributed environments. PIPS Project matches exactly the description of such environment and so it can advance from using the agent technology. To examine the idea of using agents in PIPS

and to provide objective view about the technology author conducted extensive literature survey gathering the arguments for and against the employment of agent technology to computer systems. The survey showed that although there are some concerns which slower the widespread adoption of the technology it is worth to consider applying agents to the PIPS Project. After this promising conclusion the author practically examined the applicability of agents to the project by implementing the feasibility study. This experiment also brought satisfying results. The design and implementation of distributed applications is relatively fast and facilitated. And with using JADE platform the development of agent based PIPS is worth to reflect on.

9 References

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