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INTELLIGENT PERSONAL ASSISTANTS IN A VIRTUAL LEARNING SPACE

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Abstract. *This paper presents a concept which will be used to develop intelligent personal assistants. The personal assistants are operating in a virtual education space and will be in service to teachers and students. The aim is to support the provision of e-learning services by providing a high level of customization. It is expected that the personal assistants will work on a variety of hardware mobile devices such as smartphones and tablets operating in the Android environment.*

Keywords: Intelligent personal assistants, Virtual education space, BDI-Architecture, JADE, DeLC.
Mathematics Subject Classification 2010: 68-06, 68T42.

1. INTRODUCTION

The rapid development of information technologies in recent years has led to the introduction and use of software in every sphere of life. It is no longer difficult to imagine software components that operate across networks as a kind of personal assistants, providing different services – for example, paying bills, making travel arrangements, finding information in electronic libraries, etc. For most of these applications, user acceptance will depend on customizing the personal assistant to the particular habits and interests of the user. Just as with human secretaries, their success will depend on the knowledge of the assistant about the habits and goals of the particular user, as well as on the specific set of operations and services the agent can perform. For example, an agent that has to sort incoming mail will succeed or fail, based on whether it correctly models the user's criteria for the "Urgent" mail category, or successfully separates messages related to the user's personal life from those, related to his professional life.

Similarly, the past decade has seen an enormous growth in the use of mobile devices such as smartphones and tablets. In nowadays, people are highly mobile and often out of the office; this type of go-anywhere device allows them to always be available for contact. Mobile devices have introduced a new way of personal information management which supports almost anytime, anywhere access to important information such as personal data, documents, the World Wide Web, etc. This is made possible by recent technological advances which allow these compact

devices to be equipped with reasonably powerful processors, enough memory storage and adequate battery life. They are becoming increasingly useful and widely accepted, hence more and more applications are being developed, exploiting them to their fullest.

At the present time, there are many developed intelligent personal assistants that provide different types of services – management of work schedule, mail organization, phone calls and contact information organization, etc. Some of these are:

- **MailCat** – intelligent assistant for organizing mail, developed by IBM Thomas J. Watson Research Center (Yorktown Heights, New York). MailCat encourages users to file their mail by simplifying the task. Using an adaptive classifier, it predicts the three folders that are most likely to be appropriate for a given message, and provide shortcut buttons that permit the user to file it into a predicted folder. For typical users, MailCat predictions are accurate from 80% to 90% of the time [7].
- **Siri** is an intelligent personal assistant and knowledge navigator which works as an application for Apple Inc.'s iOS. The application uses a natural language user interface to answer questions, make recommendations, and perform actions by delegating requests to a set of Web services. The software adapts to the user's individual preferences over time and personalizes results [8]. Siri started as a project of Sri International – it is a center for research and innovation at Stanford University.
- **Smart Personal Assistant Project (SPA)** – a project developed by the Australian Cooperative Research Centre for Smart Internet Technology – an organization supported by the Australian Government. The main goal of the project is a spoken dialogue application which allows users to remotely access and manage their e-mail and calendar through a natural language dialogue and a graphical user interface on mobile devices [5].

The concept of providing a high level of customization inevitably affects educational services. The requirements for modern e-learning are to provide more and more dynamics, flexibility and adaptability. Respectively, the existing e-learning centre DeLC is changing conceptually, and the dynamic distributed network structure which consist of nodes and relations between them [3], becomes a virtual learning space in which the contextual dependency of educational services will be maintained by autonomous intelligent components with reactive, interactive and proactive behaviour. For this reason there is a need to implement "new entry points" into the virtual space, namely personal assistants. Why personal assistants? – by definition, assistants provide services to help the user by performing on the user's behalf or instead of him tasks, related to his personal and professional life. Moreover, a personal assistant can be implemented as a multi-agent system, thus it can act proactively and adaptive to every specific user.

2. GENERAL ARCHITECTURE

A virtual learning space (VLS) consists of various types of software components for planning, preparation, organization and delivery of shareable, context-dependent and personalized e-learning services and e-learning content [6]. The basic architecture of the space is shown in Figure 1. A VLS consists of many different active components operating in an information environment. The last one is a combination of various information resources such as databases, digital libraries and ontologies. These active components are:

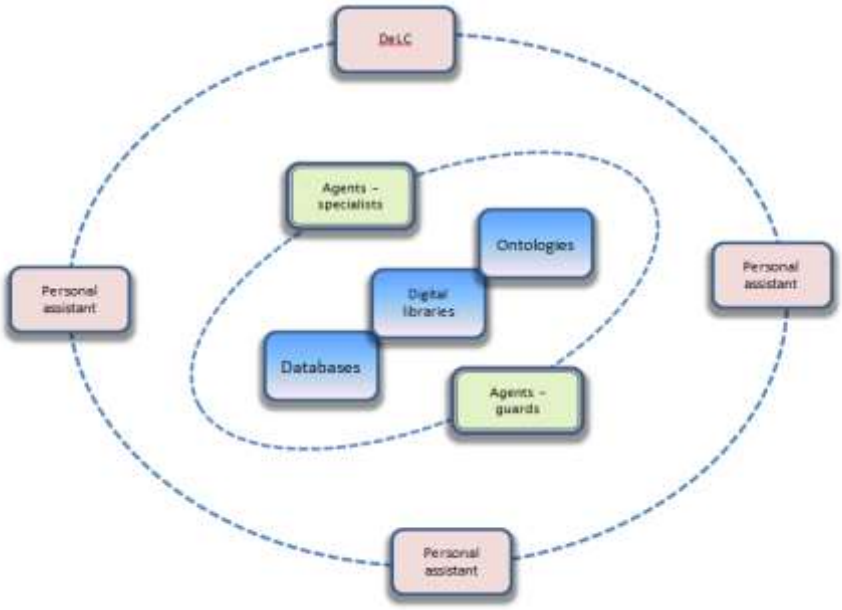

Figure 1. General architecture of a virtual learning space

- Agents-specialists – these are intelligent server agents, the main task of which is to support the educational services [6].
- Agents-guards – server agents that will be activated only in exceptional circumstances. For example, if a fire breaks out, agent-guard will notify the other agents, which in turn should take appropriate actions.
- Personal assistants (PA) – these are intelligent agents that are responsible for the communication between the users and VLS. Their aim is to provide a completely transparent structure of the space to the consumers. The access to VLS will be possible only with appropriate "entry points" implemented like personal assistants [6]. PA can operate on different types of devices, including mobile telephones and tablets.

The concept that we will use when designing and developing personal assistants is expressed by the architecture shown in Figure 2.

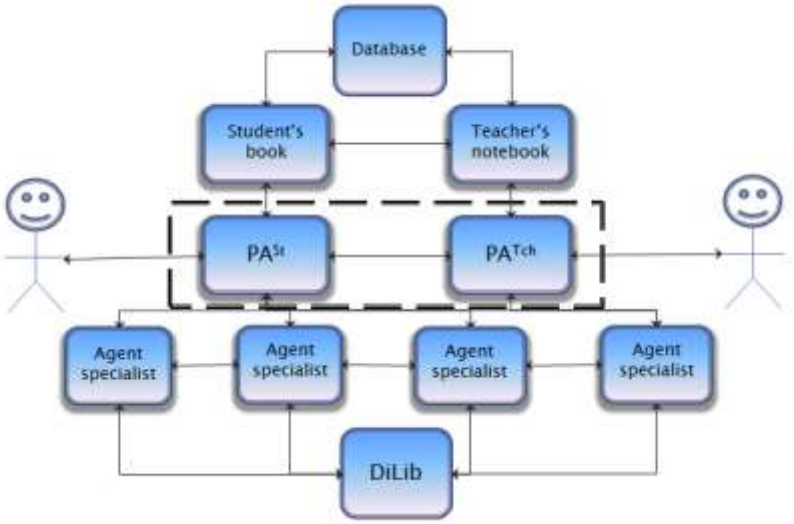

Figure 2. Communication of personal assistants with the components of a virtual learning space

In the educational process, we have two main types of participants - students and teachers. For every one of them we need to develop personal assistants which will represent entry points to the virtual learning environment. In other words – to give a user the opportunity to exploit the services of a VLS, he needs to have a personal assistant. These assistants will communicate with each other, exchanging the necessary information, related to the learning process. Of course, they will not work in isolation. On the one hand, assistants will communicate with agents-specialists which are connected with a SCORM machine and through which we can access the libraries with electronic courses. On the other hand, personal assistants will communicate with other agents which are respectively a "Student's book" and a "Teacher's notebook". Their role will be to document and record the learning process. These agents are associated with a database that stores official information related to the organization of the educational process – for a student: information about the specialty, studied subjects, faculty number, etc.; for a teacher – information about the department, lectures, classes, etc.

3. IMPLEMENTATION

As we have said before, assistants will be built as multi-agent systems. In our case, personal assistants will help users with tasks related to finding information, planning calendars and managing the educational process. Such assistant will require significant customization for every individual user. For example, an agent responsible for managing calendar events needs to know the syllabus of the consumer, his specialty and the subjects he will study. The agent that will assist in searching for the information should know the user's preferences in order to be

able to provide the necessary training materials correctly. Therefore, to implement a similar functionality, it is necessary for the assistants to be developed like rational agents or such based on BDI (Beliefs, Desires, Intentions) architecture. Beliefs represent the agent's environment. Desires are the goals that are assigned to an agent and Intentions stand for the commitments of an agent to achieve specific goals. These are the plans that are currently being implemented.

Most of the agents will be implemented as server agents (Figure 3.). An interface agent responsible for the communication with the user will have a main role.

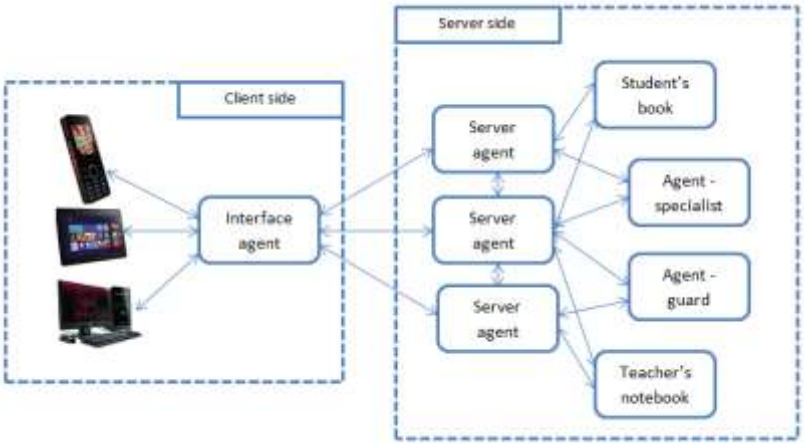

Figure 3. General architecture of a personal assistant

With regard to the internal architecture of this agent, there are several options:

- The agent is entirely located on the server – the advantages of this architecture are that there will be no need to migrate the agent and/or its states between the different mobile devices which the user would potentially use; high efficiency in processing complex tasks or such associated with processing large amounts of data – only the results will be sent to the mobile device. The disadvantages are the increased amount of traffic between the client device and the server (even for the performance of simple tasks), which in turn can involve potential security problems and jeopardize the transfer of information;
- The agent is entirely located on the client device – this approach has several drawbacks: such a system would take a substantial part of the relatively limited resources of the mobile devices; migration of the agent states across mobile devices will be necessary, which is a considerably complex and difficult task;
- The agent is distributed between the client device and the server side – this approach allows an efficient distribution of the tasks that the agent must perform as well as if there is a need of some kind of agent migration – it will

be in a minimum extent. This architecture also significantly reduces the traffic between the client and the server and allows greater flexibility and scalability of the application.

For that reason we pay attention to the distributed architecture, which is further determined by the selected technology for implementation of agents – JADE-LEAP (Lightweight Extensible Agent Platform) – originally developed by Telecom Italia. This is an extension to the basic Java Agent Development Environment, which is specifically designed for devices with limited resources – mobile devices, respectively. The LEAP add-on provides an alternative means of implementing the run-time known as the split execution mode. Working in this mode the user is not creating a normal container, but a very thin layer called the front-end. The front-end provides agents with exactly the same features of a container, but only implements a small subset of them directly, while delegating the others to a remote process called the back-end [2]. If the front-end looks like a normal container from the point of view of the agents residing on top of it, the back-end, in turn, looks like a normal container from the perspective of the other containers in the platform, including the main container. The result is that the union of the front-end and the back-end forms a container that is split into two parts, resulting in the term "split execution mode". The choice of this technology is motivated by many reasons, some of which are the following:

- the platform is developed entirely in Java, which coincides with the language used for the development of the DeLC center and the Android operating system;
- facilitates the development of multi-agent systems via an intermediate layer that is compatible with the specifications of FIPA;
- provides tools to facilitate debugging and deployment and there is a transparent communication mechanism between the agents through ACL messages;
- last but not least, JADE supports the use of many additional libraries, one of which provides the important to us BDI (Beliefs, Desires, Intentions) architecture, through which we can implement the mental states of intelligent agents, namely autonomy, social ability, reactivity, proactivity, veracity, rationality – qualities that each personal assistant has to wield.

In addition to JADE, to ensure the mental states of the agents, we will integrate JADEX. This is a project developed by the Distributed Systems and Information Systems Group at the University of Hamburg. The JADEX reasoning engine follows the Belief Desire Intention (BDI) model and facilitates easy intelligent agent construction with sound software engineering foundations. It allows programming of intelligent software agents in XML and Java and can be deployed on different kinds of middleware such as JADE [4]. These agents are capable of acting purposefully using their beliefs, desires and intentions. Besides these cognitive agents, which are especially suitable for complex tasks, JADEX provides simple reactive micro-agents which are similar to the active objects and are very

effective in terms of low consumption of resources [4]. The platform allows mixing of agents with different architecture in one application. JADEX provides a component for Android – Jadex Android. It is a framework for developing software agents running on the Android platform.

This agent that will be responsible for communication with the user should provide a convenient and intuitive interface. This is one of the reasons why we have chosen the Android platform. At the present, Android is the most popular mobile platform in the world and supports a great number of different mobile devices used in more than 190 countries around the world [1]. In addition, it offers other advantages: Android provides a very powerful development framework to building applications for mobile devices. It automatically adapts the user interface to look its best on every device, while giving the developer as much control as he wants over the whole UI on different device types [1]. There are convenient tools for developers which offer a full Java IDE with advanced features for developing, debugging and packaging Android applications. Using the IDE, one can develop on every available Android device. The environment offers an emulator of virtual devices that emulates any hardware configuration. The platform uses Java and is open source, which allows working with multiple, external, written by third-party libraries. Last, but not least, the philosophy of Android is to support an extremely high level of user customization.

4. CONCLUSION

The main approach which we will follow when developing the assistants is to develop one generic personal assistant, based on the reference architecture of the virtual learning space. For every user we should generate a specific PA that will be an instance of the genetic one. Each specific instance will have individual qualities depending on whether it is a personal assistant to a teacher or student.

ACKNOWLEDGMENT

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ИНТЕЛИГЕНТНИ ПЕРСОНАЛНИ АСИСТЕНТИ ВЪВ ВИРТУАЛНО ОБРАЗОВАТЕЛНО ПРОСТРАНСТВО

Ирена Кехайова, Пенчо Малинов, Станимир Стоянов

Резюме. *В статията е представена концепция за разработване на интелигентни персонални асистенти. Персоналните асистенти оперират във виртуално образователно пространство и ще подпомагат преподавателите и студентите в тяхната работа. Целта е доставка на електронни образователни услуги с висока степен на адаптация. Възнамеряваме персоналните асистенти да работят върху различни мобилни устройства като например, смартфони и таблети, опериращи в средата Андроид.*