An Approach to the Realization of Personalized Adaptation by Using eQ Agent System

Violeta Damjanovic[1], Milos Kravcik[2], Vladan Devedzic[3]

[1] Postal Savings Bank, 27. Marta Street 71,
11000 Belgrade, Serbia and Montenegro
vdamjanovic@gmail.com
[2] Fraunhofer Institute for Applied Information Technology FIT,
53754 Sankt Augustin, Germany
Milos.Kravcik@fit.fraunhofer.de
[3]FON, University of Belgrade, Jove Ilica Street 154,
11000 Belgrade, Serbia and Montenegro
devedzic@fon.bg.ac.yu

Abstract. The main intention of this paper is to represent one approach to the realization of personalized adaptation in professional training and learning environment. Our decentralized approach is based on using the eQ multi-agent system with the BDI agent rational model. The eQ agent system considers relevant contextual information about user's traits and user devices, as well as content information about different learning and training materials. The main aim of the eQ agent system is to enable better personalized adaptation, as well as better training and learning outcomes, by using proposed learning strategy. The potential benefits of using personalized adaptation in training environment are illustrated by using an example of fine art professional training.

1 Introduction

Personalized adaptation represents key aspect in technology enhanced learning and training communities. This implies the requirement for a reactive and decentralized platform that can make informed decisions about how to respond to changes to user preferences, device capability, enterprise policy and many other environmental factors. Roughly speaking, the main aim of personalized adaptation is to support ubiquitous, decentralized, agent-based systems and devices for learning, training, and doing well in different environments.

Development of a sharable digital library of learning and training resources can be useful in various systems, such as: computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. In the same time, there are different resources types, such as: graphical material and hypertext documents, simulations, questionnaires, exercises, presentations, research study, experiments, and much more.

In this paper, we describe an approach to the realization of personalized adaptation according to the individual user's traits, such as: personality factors, cognitive factors, learning styles, and personality types (stereotypes). Different users could have differ-

ent learning needs and preferences, they could have different knowledge levels, as well as different opportunities to use certain training methods related to the fact where both users and theirs labs are placed in physical world.

Many researchers agree on the importance of modeling and using individual traits for adaptation, but there is a little agreement on which features can and should be used, or how to use them [1]. Hence, we proposed using concepts of emotional intelligence (EQ) [2] in order to achieve adaptivity in the domain that can be collectively referred to as a "context" in professional learning and training environments. EQ represents an essential part for effective communication and adaptability, especially in the field of education to support the user to be more emotionally and socially intelligent and reduce negative behaviors.

The paper is organized as follows. After the brief introduction, we explain the role of context, content, and adaptation management in decentralized systems. Then, we describe the conceptual design and key paradigms used in proposed multi-agent system, called the eQ agent system. In the next step, we represent an example of personalized adaptation in fine art professional training environment. After that, using of the FOSP adaptive strategy for further personalized adaptation in professional training, together with the eQ agent system, is explored. The last section contains some conclusion remarks.

2 Context, Content and Adaptation Management

Based on experience from development of adaptive educational hypermedia authoring tools [3], the authors suggest that an efficient adaptive hypermedia system should contains the following parts:

Context management: It includes user modeling, enabling reusability and sharing of the user model by various adaptive applications and user devices. In other words, context management can be used to collect, collate and process context information about users. The goal of this part is to design and implement a mechanism by which context information can be updated and distributed. Context manager must be able to detect modification and addition of user's characteristics; it must have location awareness module, as well as a component that provides data about enterprise policy [4].

The approach represented here is based on modeling stereotypical models of user individual traits for adaptation. These individual traits, such as personality factors (extrovert, introvert), cognitive factors (perceptual processing, phonological awareness, ability to maintain attentional focus), learning styles (moving, touching, doing, auditory, visual), personality types (conventional, social, investigative, artistic, realistic, and enterprising personality), could be extracted by using specially designed psychological tests, performed by multi-agent system as a distributed test-sensor system.

Web environment is the perfect place to measuring EQ skills and offer new suggestions for practicing these skills. The process for developing EQ online [5] is represented in context management part of Figure 1.

Content management: It maintains the domain model (learning objects with metadata, semantic concept networks/ontologies) and supports the authoring process (separation of content and layout, their reusability, semi-automatic annotation) [6]. As an example of professional training domain we represents the ontology Accademi@Vinciana that involve solid team of experts from the area of fine art conservation and restoration, as well as physics and chemistry. It has three main parts with the knowledge should support the following:

- Learning about fine art painting methods and materials (education: painting methods and materials, conservation treatments, preventive conservation strategies, restoration, reproduction);
- Training about fine art painting methods and materials (education, classical painting technology analysis, painting damage diagnosis);
- Art Fraud e-Detection (author identification, original expertise, fraud detection).

The ontology Accademi@Vinciana will be discussed in Section 4.

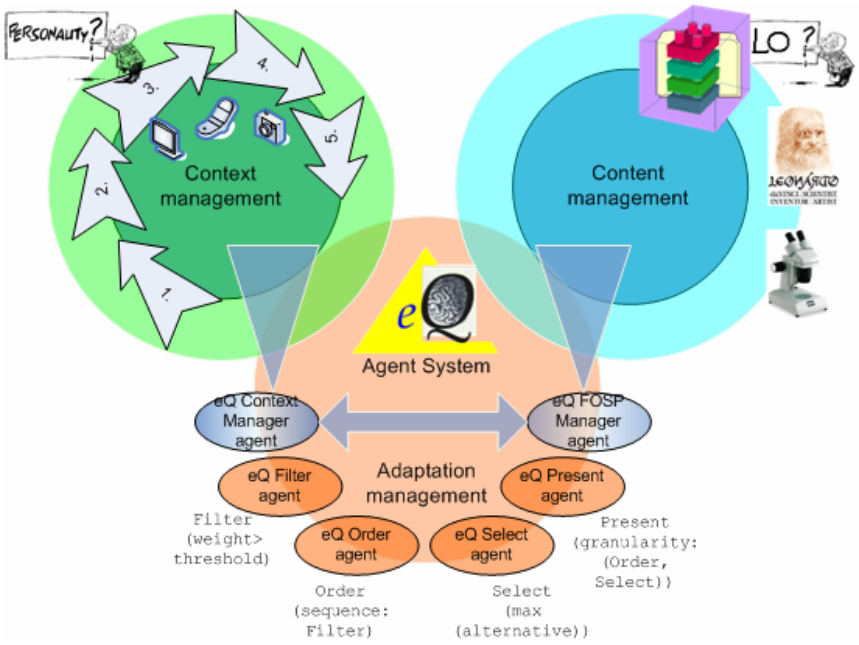

Fig. 1. Conceptual design of the eQ agent system. *Context management part* is related to the first level of personalized adaptation using EQ concepts. The process for developing EQ online includes the following: 1. Measure EQ skills online, 2. Make the online feedback & action plans personalized, 3. Allow time to practice offline, 4. Measure EQ skills online again, and 5. Offer more online development steps based on the change scores. *Content management part* includes learning objects, semantic metadata about learning materials and training devices. Adaptation management part consist of the eQ agent system, which perform the FOSP strategy

Adaptation management: Adaptation can be thought of as the behavior of an entity in response to both changes in context management and needs in content management.

The adaptation manager could be used directly by an application that pushes relevant information to a user based on the user's stereotype and user's learning and training needs. In this paper, the adaptation manager decides to modify presentation content using the FOSP adaptation strategy [6] that will be discussed in Section 3.

Figure 1 shows the conceptual design of the eQ agent system placed in the adaptation management part, as well as their relations to the both context management and content management parts.

3 Conceptual Design of the eQ Agent System

E-learning and training should provide advanced knowledge sharing and collaboration between both user profiles and user needs. It means that e-learning courses and trainings can be assembled dynamically from different repositories of learning objects and tailored according to the user profiles and their learning needs.

In this paper, we explore several key paradigms being used in conceptual design of proposed personalized adaptation approach. First, that approach is based on using multi-agent system with the Belief-Desire-Intention (BDI) agent rational model. Second, this system is initially defined by considering component-based definition of the adaptive educational hypermedia systems (AEHS) represents in [7]. Third, this system use the FOSP adaptive strategy proposed in [6]. Finally, according to the fact that we are dealing with the stereotypes of users, having in mind EQ concepts to help in adaptation to the user real needs and known preferences, we called this system eQ. In that way, we could determine eQ agent system as distributed test-sensor system, with the main aim to infer about user stereotypes, to recognize them, as well as to offer the personalized information and content wherever it happens, in online, offline or virtual training labs.

3.1 eQ: Multi-agent System with the BDI rational model

eQ represents a multi-agent system (MAS) being developed to support decentralized approach both in Web-oriented and ubiquitous environments. MAS are widely seen as the most promising technology for developing complex distributed software systems in the years to come.

eQ uses embedded BDI rational model, in which the FOSP adaptive learning strategy being implemented. eQ agents consider information about user (user group), represents as instances from the ontology for adaptation, and according to the user stereotypes, user types (schoolchildren or experts), personality factors, cognitive factors, and learning styles, they find adequate contents from the repositories of learning objects. Using eQ agent system, personalized adaptation mechanisms passes by two phases: first, personalization based on using contextual management, and second, additional personalization based on using the FOSP adaptive strategy.

3.2 eQ: Defined as an Adaptive Educational Hypermedia System

Adaptive education hypermedia system, defined in [7], represents a quadruple

$$(\text{DOCS, UM, OBS, AC}). \quad (1)$$

Each part of component based AEHS represent in (1) can be briefly described as follows [7]:

- DOCS (DOCument Space) – describe documents (and knowledge concepts), and define relations between them;
- UM (User Model) - describe individual users (or user groups) and user characteristics, and formulas in order to express whether a characteristic applies to user;
- OBS (OBServation) - describe observation, and relations between users, documents/knowledge concepts, and observations;
- AC (Adaptation Component) - describe adaptive functionality.

A decentralized user model (UM) could be formed in continual following of user's physical movements, as well as user's history of preferences from the ontology for adaptation. For example, participation of user Pj in certain online training OEi could be done when user's personality type satisfies a set of psychological requests, such as: introverted, extroverted, etc. If we have an artistic personality with introverted perception, implying the usage of the following keywords: `inner_world, ideas, images, memories, reflection, depth`, the rule for processing the observation (OBS) can be expressed within the simple UM in the following way [2]:

$$\begin{aligned}
&\forall \texttt{OEi}\ \forall \texttt{Pj} \\
&\texttt{observe(OEi, Pj, inner_world)} \vee \\
&\texttt{observe(OEi, Pj, ideas)} \vee \\
&\texttt{observe(OEi, Pj, images)} \vee \\
&\texttt{observe(OEi, Pj, memories)} \vee \\
&\texttt{observe(OEi, Pj, reflection)} \vee \\
&\texttt{observe(OEi, Pj, depth)} \\
&\Rightarrow \texttt{type(OEi, Pj, artistic_personality)} \qquad (2)
\end{aligned}$$

The adaptation component (AC) will be discussed in the Section 4.

3.3 eQ: Using the FOSP Adaptation Strategy

FOSP method is based on using a pattern identified in the adaptation process that consists of four operations: Filter, Order, Select, and Present [6]. The main idea is to separate the partial results produced by different authors in such a way that they can be reused. FOSP method consists of the following three levels [6] shown in Figure 2:

Level 1 - Operations: `filter` (selects just those components that have their `weight` greater than `threshold`), `order` (sorts the selected components according to the `sequence` value), `select` (chooses that one component with the highest `alternative` value), `present` (displays the componets taking into account the `granularity` value);

Level 2 - Functions: `weight` (the relevancy of the pedagogical `role` for the learning style), `sequence` (the presentation order of the `role` for the learning style), `alternative` (the relevancy of the `media` type for the learning style), threshold (the `threshold` for the object display based on the learning style), `granularity` (the max number of objects presented for the `context`);
Level 3 - Sets: `role`, `style`, `media`, and `context`.

The aim of each of the above-mentioned levels in creating a flexible and ontology-powered agent system to support better adaptation and e-learning mechanisms will be explained in the upcoming Section 4.

4 Fine Art Professional Training: Accademi@Vinciana

Long years ago, methods and techniques of creating artistic work had been mainly related to the artistic workshops and classes. One of the first art academies was founded in 1494 by the renaissance *uomo universale* – Leonardo da Vinci [8]. Leonardo's art academy was known as *Accademia Leonardi Vinci* or *Accademia Vinciana*. This academy had gathered a large crowd of painters, as well as scientists - to discuss problems concerning art and science.

Nowadays, the way of learning about fine art painting methods and materials is notably different from the past. Medieval painting methods are simplified by contemporary methods, but the process of becoming fine artist still represents hard work. The young artist has to acquire a lot of different theoretical and practical knowledge background, to get valid and precise information, based on contemporary artistic trainings.

The main idea presented here is to implement a novel art academy based on using Semantic Web possibilities and assembling different sides of artistic communities in a technology advanced fashion.

4.1 Accademi@Vinciana Ontology

Accademi@Vinciana ontology has several dimensions concerned professional training's intentions. First, this ontology describes three fundamental painting components and theirs role in painting construction. These components could be explained as follows: colors (represent main artistic instrumentation), ground (represents the base, the underlay of painting) and binder (represents an important factor to firm adherence of colors to the ground). Second, this ontology observes fundamental aspects for analyzing painting methods and techniques. These aspects can be considered as follows [8]:

- Purpose and usage – icon, miniature, illumination, altar painting, …
- Ground material – stone, tree, glass, ivory, parchment, canvas, paper, cardboard, …
- Binder and colors: chalk, carbon, aquarelle, pastel, tempera, oil, encaustic,
- Painting tools – quill, cane, brush, air brush, artistic knife, aerograph, …
- Painting methods and techniques – *proplasmos, glykasmos, verdaccio, puntegiaro, trattegiaro, fa presto, impasto, alla prima, collage, frottage*, ...

Third, Accademi@Vinciana ontology can be divided into the following two categories of trainings [8] (shown in Figure 2):

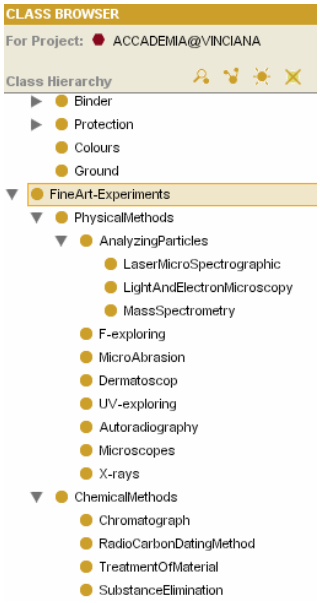

Fig. 2. One part of the ontology Accademi@Vinciana

Trainings made by using physical methods: It includes trainings that are performed using:

1) Dermatoscope: non-invasive diagnosis;
2) Microabrasion equipments: for drilling micron level holes, for cutting or marking fragile or otherwise difficult materials;
3) Microscopes: for histological analyzing of paintings;
4) Exploring the nanostructures of painting materials with X-rays: this method show solid results in uncovering of fraud, as well as in exploring the way of building paintings;
5) UV exploring: it can be used to learn process of building paintings up to identification of original;
6) Fluorescent microscope (F-exploring): it can be used to explore homogeneity of varnish and other transparent layers;
7) Analyzing particles (protons, neurons): ESA (Emission Spectral Analyze) (laser), Laser micro spectrographic analysis, Light and electron microscopy (scanning), Mass spectrometry, DBA (Debye-Scherrer Analyze) (analyzing small particles);
8) Autoradiography: it can be useful for microscopic fluorescent measurements.

Trainings made by using chemical methods: It includes trainings that are performed using:

Microchemistry approach with pigments identification, emission spectral analysis, the iodine probe, DBA …

9) Chromatograph – substance that reacts on certain components (for example, if the reagent is protein, substance will be colored red).
10) Exploring substance elimination - binders have different behaviors when they are heated in water (wax is smelted at 60ºC, oil at 160ºC).
11) Different treatments of certain material – burning samples, exposing samples to the rays of the sun or to the X-rays, high temperature, …
12) Radio carbon dating method: one of the most widely used and best known absolute dating methods, based on the decay rate and half-time of C-14 (an unstable isotope of carbon).

All of these physical and chemical methods and devices could be used to explore and make artistic trainings in order to learn about painting methods and materials, as well as to explore and diagnose conservation strategies, originality, author identification, forgery, and much more.

4.2 Using eQ Agent System for Adaptation in Fine Art Professional Training

When user starts application for fine art training and learning, this application automatically recognizes both user's individual traits and user devices on which the application is executed. All information about user's characteristics is contained within the ontology for adaptation (as context information), previously extracted by distributed personality test-sensors. An `eQ Context Manager Agent` finds all context facts about observed user and sends these results to the `eQ FOSP Manager Agent` in order to perform personalized adaptation and present adapted content information to the user. `eQ Context Manager Agent` has a location awareness module, which role is to support changes in user device attribute values. For example, user starts using training application on laptop, and then migrates to a PDA. It means that the content information have to be additionally adapted and the `eQ FOSP Manager Agent` has to perform some kind of filtering which shrinks the images to a size that fits nicely on the screen of the PDA.

For example, the application for fine art professional training recognizes user with the "*artistic personality*" (personality type), "*introverted perception*" (personality factor), "*visual*" learning style, which user type is "*expert*" that explore "*art fraud*" and uses "*PDA*" (user device), then the first level of contextual personalized adaptation is finished. Now, it should be done content adaptation for that user, what is the task of the `eQ FOSP Manager Agent`. `eQ FOSP Manager Agent` supervises four eQ agents that one after the other perform the main operations of the FOSP adaptive strategy, such as: Filter, Order, Select, and Present. The `eQ Filter Agent` starts to perform `Filter` operation by selecting just those components that have their `weight` function greater than `threshold` function. Both of these functions are related to the semantically annotated FOSP sets that represent content from both the ontology for adaptation and the ontology for learning (or learning objects). `eQ Filter Agent` sends the filtered components as a result to the next agent - `eQ Order Agent`, which perform `Order` operation by sorting the selected (filtered) components according to the `sequence` value. It sends a sequence of the selected components to both the `eQ Select Agent` and the `eQ FOSP Manager Agent`. `eQ`

`Select Agent` performs `Select` operation by selecting from the set of alternative components one with the highest `alternative` value, and finally, `eQ Present Agent` performs `Present` operation according to having the `granularity` value from the sets of selected or the alternative components. All values of considered FOSP functions, such as `threshold, weight, alternative, sequence, granularity`, are related to the ontology concepts, such as `Role, Style, Media, Context` (FOSP sets).

Fine art trainings based on using physical methods could be realized with different optical tools (microscopes, dermatoscopes, micro-abrasion equipment, equipment for UV and F exploring, cameras). In the case of the above explained user, the `eQ Present Agent` brings some physical methods for fine art trainings as a result. Actually, it means that the `eQ Present Agent` offer trainings by using X-ray, UV exploring, as well as F-exploring, as training methods that could be used in order to achieve art fraud investigation.

All points of the considered eQ agent system, which uses the FOSP method for personalized adaptation, are shown in Figure 3.

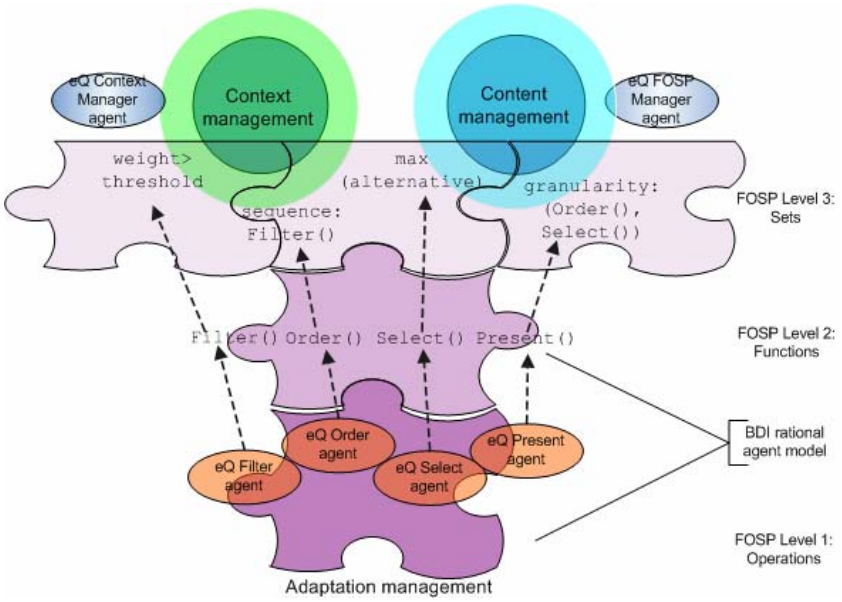

Fig. 3. eQ agent system uses three levels of the FOSP method: operations, functions, and sets. Levels one and two can be directly implemented through the eQ BDI (belief-desire-intention) reasoning engine. It means all triggering events and beliefs must be specified in the Agent Definition File (ADF) which role is to let the agents known what kinds of events they must handle.

5 Conclusion

The process of training and learning in Web-based and ubiquitous environments brings a new sense of adaptation. With the development of more sophisticated environments, the need for them to take into account the user traits and user devices on which the training is executed, and to place them within the context of the training activities has become an important issue in the domain of building novel training and learning environments.

In this paper, an example of fine art professional training is used to illustrate the potential benefits of using personalized adaptation in training environment. As the potential benefits, we can mention the following:

- Adaptation by focusing on the main subjects from the domain of artistic training (painters, conservators, restorers, technologists, fraud investigators);
- Using all available resources (learning materials, training devices) wherever the user is physically located;
- Exploring ancient and current technologies in order to find better solutions;
- Analyzing generated results and deciding about using preventive painting strategies;
- Collaboration in order to achieve the original expertise and art fraud investigation.

References

1. Brusilovsky, P.: Adaptive Hypermedia. User Modeling and User-Adapted Interaction, Vol. 11, No. 1-2, (2001) 87-110
2. Damjanovic, V., Kravcik, M., Gasevic, D.: eQ Through the FOSP Method, In Proceedings of the ED-MEDIA 2005 World Conference on Educational Multimedia, Hypermedia and Telecommunications, Montreal, Canada (2005)
3. Kravcik, M., Specht, M., Oppermann, R.: Evaluation of WINDS Authoring Environment. In Proceedings of the Adaptive Hypermedia 2004 Conference, Eidhoven, Netherland. Springer (2004)
4. Robinson, R.: Context Management in Mobile Environments, thesis (2000)
5. Bradberry, T., Greaves, J.: Can you develop emotional intelligence online?, TalentSmart Inc, (2003)
6. Kravcik, M.: The Specification of Adaptation Strategy by FOSP Method. In Proceedings of AH2004 Conference, Eidhoven, Netherland, (2004)
7. Henze, N., Nejdl, W.: Logically Characterizing Adaptive Educational Hypermedia Systems. In *Proceeding of the International Workshop of Adaptive Hypermedia and Adaptive Web-based Systems (AH 2003)*, Budapest, Hungary (2003) 15-28
8. Kraigher-Hozo, M.: Painting / Painting Methods / Materials. Svjetlost, Sarajevo (1991)