Adaptation for enriching services taking into account mobile contextual features

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ABSTRACT

One of the current challenges in information technology is to provide instant access to relevant information, without being limited by the location of the user or the device used to retrieve it. Current technologies allow users to access an overwhelming amount of data. This is an undesirable situation, since it is very difficult for users to obtain relevant information from these data. Enriching the user experience, which means, adding criteria such as user preferences and characteristics of his/her mobile context of use (*e.g.*, location, access device features), can solve the aforementioned problem, since the information can be better adjusted to user needs and space-time situation, reducing the volume of information received by the user and avoiding information overloading. This paper presents an approach to enrich the user experience called ***A***gents for ***E***nrichment ***S***ervices (*AES*), an adaptation framework based on agents that provides users with information tailored to their specific needs, features, devices, and context, with the purpose of giving relevant information at the right moment, place, and device.

Categories and Subject Descriptors

D.3.3 [Language Constructs and Features]: Frameworks – adaptation framework, context information.

Keywords

Services, mobile, context, profiles, generic, adaptation.

1. INTRODUCTION

Adaptation is a process that addresses the cognitive overload of a user that receives huge volumes of information from multiple information systems [4]. Generally, those systems do not consider characteristics of the user, such as preferences, interests, *etc*. to solve queries [13]. As a consequence, the information is presented to every user in the same way, without taking into account his mobility, preferences and other characteristics.

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The purpose of the adaptation of information is to enrich a service by adding a set of parameters (relevant features that might influence the user interaction) to provide the information according to the needs of the user and his context (for this paper, context refers to the set of features that can influence the user's interaction with the system [1]). These parameters are obtained using high-abstraction processes (e.g. inferences, deductions) and are utilized to customize the user query. The volume of information retrieved by this technique is significantly reduced, due to the query parameterization, which considers user location and access devices.

There are several issues to adequately adapt the information to users. First, the design of the existing tools of adaptation is attached to specific scenarios or applications (*e.g.* education, health). This situation hinders the application of these tools in other scenarios [9][14][15]. Moreover, these tools do not consider the nomad characteristics of the user (mobility and display problems) [10]. Besides, there is not a generic tool for adapting the information by considering the mobility aspects of the user.

To address these issues, this paper presents *AES* (***A***gents for ***E***nrichment ***S***ervices), a generic framework for adapting information in mobile contexts [12]. *AES* can be used by an application that needs to enrich services to provide the user with information adjusted to his needs and context. Figure 1 describes the overall approach. An external application (managed by a user or by another system) sends an Initial Query to *AES* and requests to enrich it.*AES* obtains profiles of relevant characteristics of the External Application (user, context, devices) and invokes filter functions according to the selected profiles. The result is a set of highly-abstracted data that is utilized to generate an Enriched Query that will be sent back to the External Application.

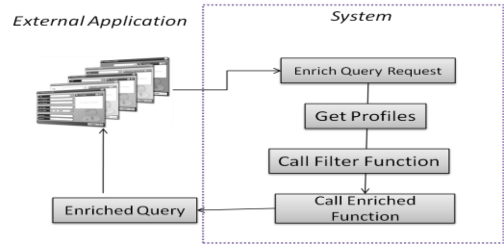

Figure 1. *AES* General Operation

2. *THE AES FRAMEWORK*

AES framework considers user access device and context with the purpose of provide relevant information on the right moment, place and device (mobile or not). *AES* is part of a project called *ASMA*[1], which is an agent-based platform for application development built on *BESA* [8]. *ASMA* has an agent internal architecture that manages a synchronic event-based communication between agents and a cooperation and social structure between agents. *ASMA* and *BESA* facilitate the development of complex applications because they divide the problem in self-independent modules, which interactions are structured and clearly specified.

Even though *AES* was created over *ASMA*, it can be used by any other system. The pre-condition to use it is to previously define the adaptation mechanisms and filters required to execute the adaptation process.

2.1 Architecture

The inputs of *AES* are *i)* the **Basic Query** (***Q***) that the user makes to the adaptation module, *ii)* the external information (***Context Information***) such as the access device used, the environment characteristics or location in which the interaction of the user takes place, *iii)* the particular exceptions (called ***Restrictions***), which means the context variables affected by some boundaries or restrictions because of the interaction of the user with the system and *iv)* a ***Feedback*** to the system, which can be a *manual result feedback* or *automatic result feedback* made by an external system related to the quality on the output.

The system generates a new ***Enriched Query*** with new elements to improve the basic query. If the basic query could not be enriched, the output will be the same as the input. For more information about the architecture of this framework, see [3].

2.2 Design test scenario

In order to explain in detail the system functionality and to prove the interactions within the model, this section explains a test case in a learning system. The objective of the test is to use *AES* to enrich the service: select a Virtual Learning Object (*VLO*) for a specific student (this is the *Basic Query*).

Assume that the teacher of a History class wants to select the best *VLO* the student John. John accesses the system through his cell phone (*Context Information*). The different profiles (*AIS*) that the system stores are: the student and device (e.g. cell phone) profiles. From these profiles the system will select those which will be used to enrich the initial query (through the *AISManager*), in this specific case, the selected profiles would be John's profile and the RT50's profile that corresponds to the cell phone that John is using to access the system.

The first filter receives John's profile, which contains a large amount of information such as name, display preferences, basic learning style, *etc*. This filter separates relevant information according to the context. The second filter receives the device's profile, which contains information such as reference, battery level, supported formats, *etc*.; this filter will also separate relevant information according to the context needs.

Using rules and the previously obtained data, the first filter deduces that John has an active-visual learning style according to the Felder-Silverman test [19] and it would return information about the active-visual material that matches John's display preferences. The second filter will make the same process as the first filter and it would return information telling that the device has a low screen resolution, so it is a small device.

Considering that the learning style is active-visual (i.e. he learns through visual stimuli and in a active way), and the access device has a low screen resolution and small size, the system deduces that the selected *VLO* must be a figure or a dynamic *VLO* and its size and display resolution must be small (Enriching Function). After receiving each filter result (learning style, cell phone size), the system applies each filter result as stated by the adaptation mechanism's rules, which determine the importance and order in which results must be applied.

In this case, the Device Filter is executed first, followed by the User Filter: The device resolution is low so the system deduces that the *VLO* presented must be in a low resolution format and have a low size in *KB*. Additionally, according to the fact that the visual information is the kind of information that best fits the learning method of John, the system deduces that the *VLO* must contain figures and interactivity (*Adapter*). The Adapter then yields an enriched query that comprises the active-visual material that matches the preferences of John (*Enriched Query*). For example: simulations, experiments and self-assessments in low resolution and text format (see Figure 2).

In order to give feedback to the system and improve its adaptation process, it is necessary to evaluate the result (*AISBuilder*). To achieve this task, the system checks whether John has chosen one of the results provided by the enriched query or not (*Automatic Result Feedback*). Additionally, the system can evaluate the usefulness of the information through a test answered by John himself (*Manual Result Feedback*).

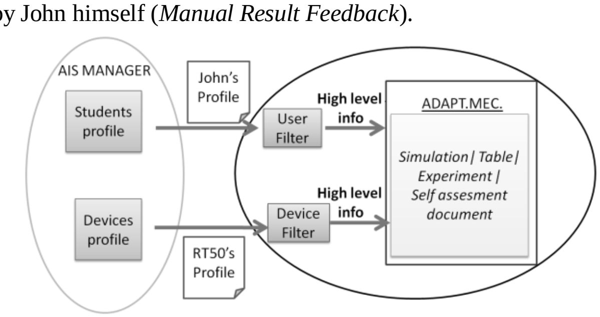

Figure 2. *Adaptation Mechanism* Result.

3. DEVELOPMENT

The agent model of this framework is shown in Figure 3. The dynamic components were implemented by software agents due to their artificial intelligence capacity and proactive actions that aid them in their goal achievement process [5]. The rectangles represent static components. The Environment, depicted as a cloud, represents all of the external sources that use and give feedback to the *AES* framework. For more information about the agents development of this framework, see [12].

4. CASE STUDY

This section presents the improvement of the information obtained using *AES* in order to test its adaptation functionality.

4.1 Test scenario without adaptation

When a user enters a query into an information source, results are not customized. If the teacher needs to select a *VLO* for John,

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[1]*ASMA*, acronym in Spanish of Architecture for MultiAgent Systems

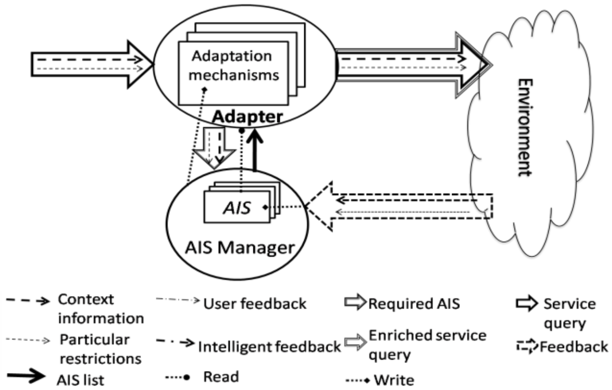

Figure 3. Agent Model

he receives a lot of material regardless of the best way that John learns, among other characteristics of John that could guide the query to what he really needs. For this reason, the information the teacher receives from an information resource after performing the query “History *VLO*" is in the order of millions. These results are general and presented to any user who requests the same query, whether the user is on a mobile device or not (Figure 4).

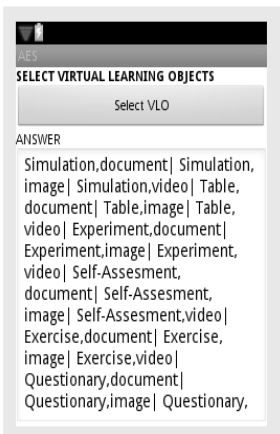

Figure 4. Virtual Learning Object (*VLO)* Selection without Adaptation

4.2 Test scenario with adaptation

Using *AES* (Figure 5) integrated with an information source, the cognitive overload decreases. The results are more specific because the enriched query has information about the *VLO* type that matches John preferences, his learning style (active-visual) and device restriction (low resolution, small size).

The test used two profiles: device and student profile. Its attributes are: *i)* Learning style: ways of learning that improve student results [19]; *ii)* Display preferences: depending on the device size, which material type the student prefers; *iii)* Format preferences: according to the display preferences (*e.g.* video), which type of format he prefers (*e.g.*mp4).

Each *Filter* has a category that corresponds to a profile type. Filters are applied only if the filter type matches the profile type. Therefore, the filters that were implemented were student filter and device filter, according to the *AIS* created. Those filters were made using a rule engine called Drools [7] which allows the creation and execution of rules for making deductions [11].

Figure 5. AES Mobile Interface

The first rule was based on the learning style [19] according to the LOM standard [6] for VLO (see Figure 6). The rule engine obtains the best VLO material type for the student. The results of the above procedure are the input of a method that adds to the VLO material type, the display preferences of the student. This is to provide the best VLO for learning as high-level information.

```
rule "Active- visual Learning style"
    when
        $student: StudentProfile(learningStyle[0]=="Active")and
        StudentProfile (learningStyle [1]=="Visual")
        $vlo : VLOtype(ActVisStyle[0]=="Simulation")
    then
        for (int i=0; i<$vlo.getActVisStyle().length; i++)
            $vlo.addMaterial($vlo.getE ActVisStyle()[i]);

end
```

Figure 6. Example of a Learning style rule

Finally, the *Adaptation mechanism* merges the high level information generated by the filters. In this case, it receives from the *student filter* the *VLO* material types with the student display preferences and from the *device filter* the device size. The *Adaptation mechanism* takes both answers and validates them. This validation consists on selecting the *VLO* material types with the student display preferences that match the size of the device. The purpose of this action is to ensure the support of the *VLO* format on the device. For example, if the device is small, the only student display preference that will be taken into account will be the preference for small devices.

The adaptation process starts when a query arrives containing context information. In this case the context has user type information (John) and access device information (RT50)**.** The *AIS Manager* searches its data and finds the adequate profiles; next, it sends each profile to a filter that matches its type (*e.g.* user-type profile with user-type filter)

Filters separate relevant information from the profile and, by executing a rule-based reasoning; they produce high-abstraction information, more relevant and meaningful to the context. The high-abstraction information is sent to the Adapter, which merges it along with other rules that take into account all the filter results. Finally, an Enriched Query adapted to the user context is generated as a final result.

It is important to note that: i)AES was tested in a mobile environment but the application that uses AES is the responsible to have the mobile interface and ii) the results can change depending on the device characteristics.

5. RELATED WORK

The adaptation information is a process that considers multiple variables in order to generate changes in a particular entity for the purpose of enriching the required information. This section presents some related work about systems that adapt the information considering characteristics related with mobility.

The notation '+' is used if the work considers the aspect, "++"if the work strongly considers the aspect and '-' is used if the work does not consider the aspect.

Table 1.Comparison between related works and *AES*

	[18]	[2]	[16]	[17]	*AES*
Generic system	-	-	-	-	++
Contextual information	++	++	++	+	++
User Information	+	++	+	++	++
Access device information	+	-	-	-	++
Mobility	+	+	+	+	++

Additionally to the criteria evaluated on Table 1, some applications do not provide the possibility of adding new parameters to the service based on custom information [1][17] and they are not flexible with the integration with other technologies[16][18]. *AES* considers these limitations and can be applied in different scenarios and different domains, considering the user's characteristics, location and device at the same time.

6. CONCLUSIONS AND FUTURE WORK

AES is a generic framework that adapts services using basic inputs and provides a transparent and customized user experience. *AES* considers different profiles, which allow the adaptation of information in nomadic environments. The information included in these profiles is taken into account to improve the information display in mobile devices and to filter out information that could be irrelevant for the user. Due to its ability of using generic filters and adaptation mechanisms, AES can be used in different kinds of environments. All of these components can be extended for the particular requirements of the service that needs enrichment. Additionally, as the case study presented, an external system can use *AES* to provide an adapted answer according to user time, place and contextual features.

Future work includes integrating *AES* with different projects and make performance tests over the adaptation process in other scenarios (*e.g.*, health, enterprises and crisis managements).

7. ACKNOWLEDGMENTS

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