Mobility in an e-learning context: Distributing Information Depending on Geographical Localization and User Profile

Jean-Yves Tigli* and Stéphane Lavirotte**
MAINLINE project
Laboratoire I3S – UNSA CNRS
Bâtiment ESSI
930, Route des Colles
06903 Sophia-Antipolis CEDEX
France
*: I3S & ESSI, tigli@essi.fr **: I3S & IUFM de Nice, lavirott@unice.fr

Abstract

One of the new challenges of learning in a partly-networked world is to open the field of mobility for e-learning applications. Currently, a large majority of applications are developed for ``PC-like" computers connected to the Internet with high bandwidth, interacting with the user through mouse and screen. But with the emergence of wireless connectivity and small devices one can think to other type of applications for education.

The aim of this paper is to present the possibility of distributing information to users depending on their localization, attitude and profiles.

We first present requirements for mobile e-learning systems, integrating constraints due to mobility and new challenges in man-machine interfaces. Then we describe our approach and validate it in a mobile e-learning application. Finally we enumerate the perspectives of such an approach and describe future work.

Introduction

MAINLINE project

Non-linear information and its applications to e-learning correspond to a real need, both from public education and private industry. Even if technology can improve applications and delivery tools, content creation is still the most important point. Without content, multimedia has no reason to exist. Creators, more and more involved using technology, need tools to simplify creation and to increase efficiency. One part of MAINLINE research is oriented towards the study and development of tools to create content (*authoring tools*).

Most web content is just the result of "*something to html*". For effective interactive presentation, tools are needed for generating and manipulating non-linear content (*dissemination agents*).

The user is all-important, because if he does not use the product, any technological benefits remain sterile. In a user-centred approach, technology should allow personalisation of content depending on user needs, to create and deliver adapted content to "the client" (*end-user agent*). Thus, a second research aim of the project is to deal with ergonomic use of content.

The following figure presents a global overview of a classical e-learning process (Figure 1).

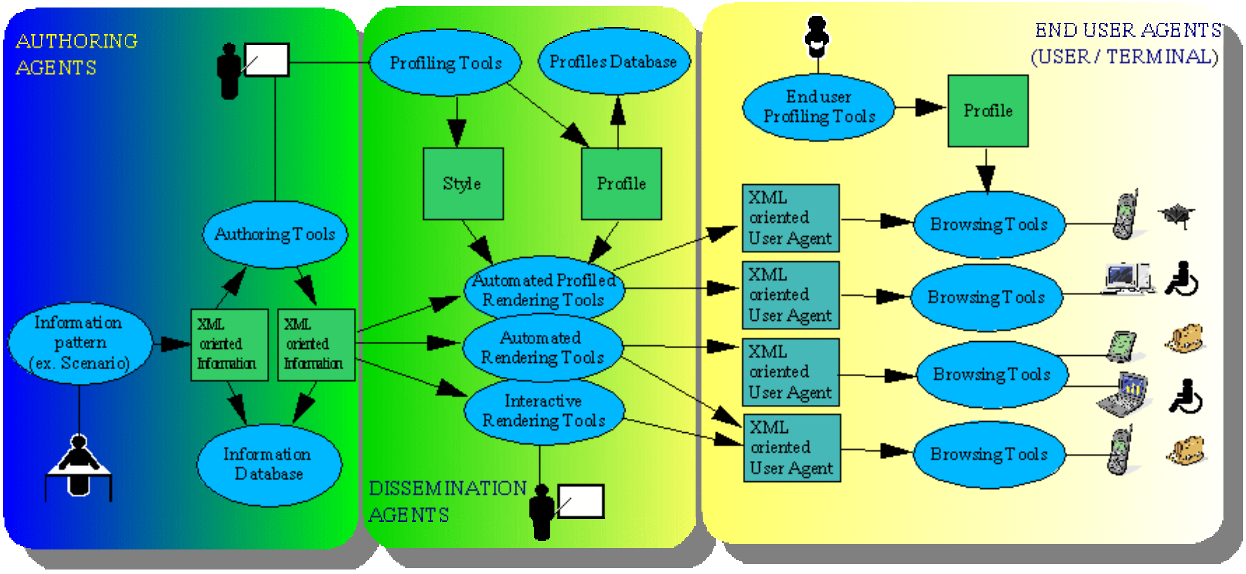


Figure 1: Global overview of a classical e-learning process

But this global approach could have some variations depending on the taught topic, particularly in experimental sciences.

Field e-learning: definition and challenges

By field e-learning we want to address the possibility for students to have the benefits of “classical e-learning” processes outside a classroom. This means that students do not have access to desktop computers but have specific or dedicated small devices. Moreover the process or learning benefits from contextual delivery of information.

A first consequence is the dependence between information delivered to the user and his local field environment (a mathematical formula is always true or false, while the name of a mountain depends on what mountain you are looking at).

A second consequence is connectivity weakness. The user is not always connected or perhaps connected with only low bandwidth, not allowing the transmission of multimedia pedagogical information. This implies a preparation of the pedagogical field mission, storing “all necessary” data on the embedded system.

End-user agent: context dependence

A major difference between a classical approach for end-user agent and a new one for field e-learning lies in the increased importance of user context (local environment, location, etc.) in the way to choose delivered content.

Context-independent approach

In a context-independent approach, delivered content should be adapted, in any case, to the end-user agent. There are two kinds of transformation.

- Structural transformations due to the user profile. This will allow presenting data specifically adapted to a given user, depending on his skill, his knowledge, etc. For example, in a given document, such a system can add or mask part of the information. This technique is known as “adaptative hypermedia” (De Bra 1999).

- The user agent cannot visualize all types of data (due to hardware or software limitations), so there is a need to adapt delivered content to the possibilities of the device and browser. To give an example, consider the case of mathematics. There is a specification of a mathematics exercise on the service side (using MathML for example) and the browser does not have any plug-in to directly visualize MathML. So there is a need to adapt the delivered content for the user to be able to visualize it, as an image or an SVG document (Broeglin 2002). As explained in (Thevenin 1999), “the term "plasticity" is inspired from the property of materials that expand and contract under natural constraints without breaking, thus preserving continuous usage. Applied to HCI [Human Computer Interface], plasticity is the capacity of an interactive system to withstand *variations of context of use* while *preserving usability*.”

In short, the adaptation to end-user agent, generally a mobile device like a PDA or a mobile phone, requires a way for transmitting information to any user-device. This is device independence (W3C 2002).

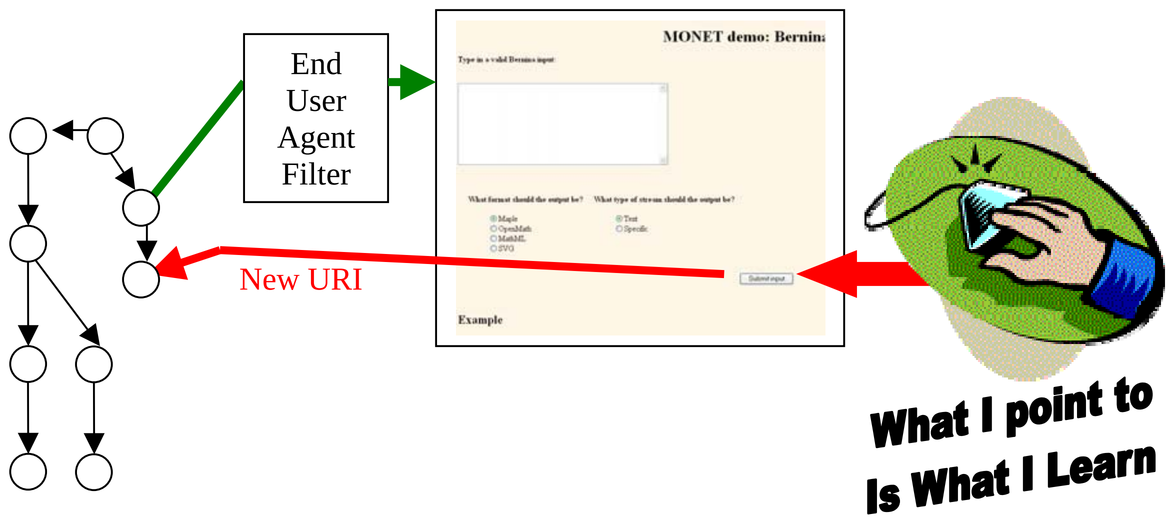


Figure 2 : End-user context-independent approach

Various e-learning domains don’t need anything more than communicating knowledge in using some form of multimedia, interacting directly with the user’s mind without consideration to environment, location, physical body.

In contrast, other e-learning subjects require adding user specific context to give relevant information.

Context-dependent approach

User mobility offers larger perspectives than just bringing a laptop computer for achieving classical or dedicated tasks. Small devices with storage capacity and wireless connectivity open the field of bringing e-learning outside the classical classroom: “every time” and “every where” a system can assist the mobile user in all his activities and especially deliver information (pedagogical or not) depending on his context (local environment, location, etc.) and profile.

For example, in a context-independent e-learning process (Figure 2) the user can directly point to the most interesting of the proposed links (*What you point to is what you learn*), even if these links are dynamic, depending on a user profile for example. In addition, in a context-dependent approach (*What you see and feel is what you learn*) the proposed information depends on several user context parameters, such as user localization, orientation, etc.

Figure 3 illustrates the context-dependent approach. When the user is near and oriented toward a relevant site, the system computes the best match between user context (and profile) and the available information stored in the end-user device.

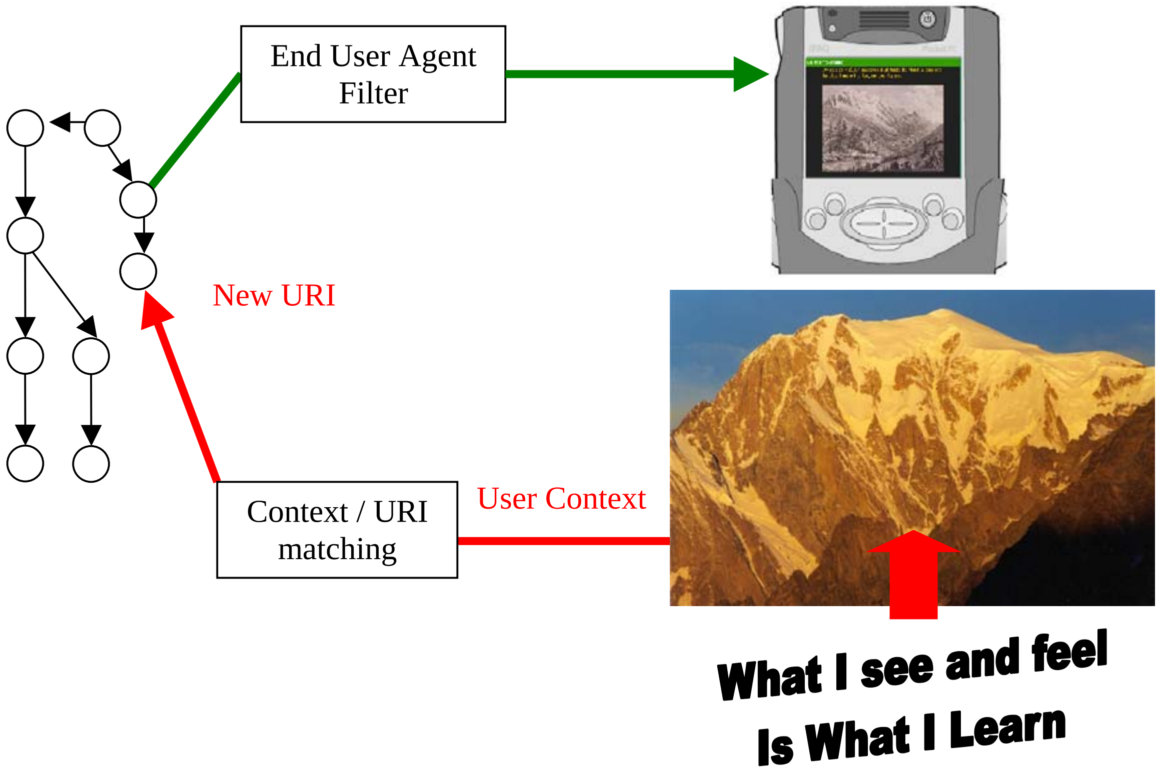


Figure 3 : End-user context-dependent approach

Dissemination agent and collaborative work

Connectivity weakness

Field e-learning implies mobility of the users and often entails a not always reachable network, even for cellular mobile phones, or a network with low bandwidth. Management of such constrains forces dissemination agents not only to format information for the end-user device, but also to anticipate the needed knowledge to store on the device. This implies preparing the pedagogical mission by caching information on the device.

Even if this process is optimum, there is always a need for low bandwidth connectivity even though this is not continuously available. This permits sending complementary information during the mission and much more, e.g., sending modifications to the mission by the teacher.

Collaborative work

These pedagogical missions can have two different objectives. The first is of course to teach something to learners during a pedagogical exercise. But, at the same time, learners can collect complementary information (like photos, notes, comments… etc). Upon return, collected information can be added to the knowledge database and could be used by others during subsequent missions. Much more, information collected in the field contains very rich contextual information. For example, if a user took a photo, we have of course, the date and time, but we could also have the geographical information, information about the weather (temperature, pressure…etc), depending on sensors embedded in the mobile device.

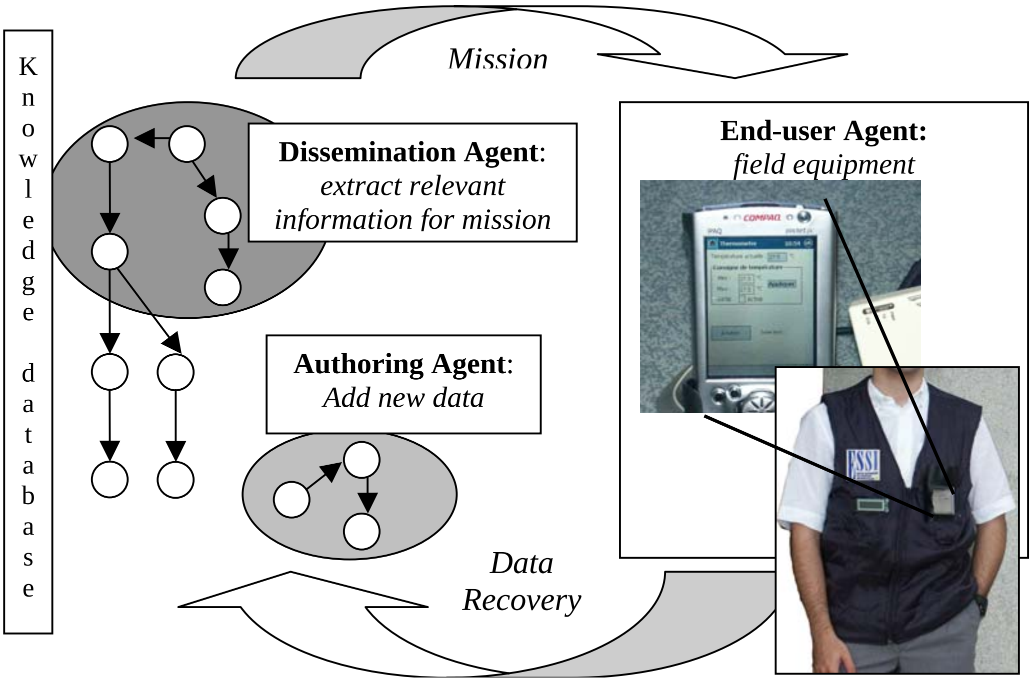


Figure 4: Mission preparation and data recovery

Wearable computers as end-user agents

Why wearable computers?

Currently, there is a transition from desktop computers or workstations to mobile devices. These mobile systems try to reproduce the functionalities used on the desktop (PDAs) or are limited to one special task like distant communication (cellular phones, for example).

However, user mobility offers prospects which largely exceed the simple possibility of transporting a computer for traditional or dedicated tasks, but can lead to using computers in unsuspected ends: assisting a mobile user in all his activities whatever they may be.

Such computer systems are named with the generic term of wearable computers (Starner 2001), (Siewiorek, 2003). They are not restricted to "communicating wear", which aim is to assure the continuity during audio or video communication even if the user moves, or "intelligent wear", which aim is to provide regulation and control of biometrical parameters of the user.

Thus, the wearable computer is a multi-form system to develop the following features:

- to offer multi-modal interfaces for the user,
- to adapt its activity and interface to the user,
- to adapt itself to the local context depending on the environment,
- to adapt the available resources depending on the connectivity and its state,
- to communicate and store information.

The principles of wearable computer architecture are:

- Hardware components should be connected to a computing system constituting hardware and software components of the application. This allows among other things, getting information about the environment.

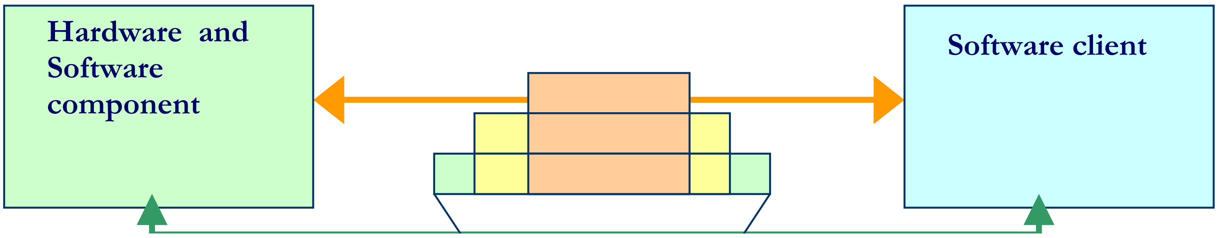


Figure 5: Hardware / software component

- A global information system which stores information about the visited environment for example.
- A user profile system adapted to the specific application.

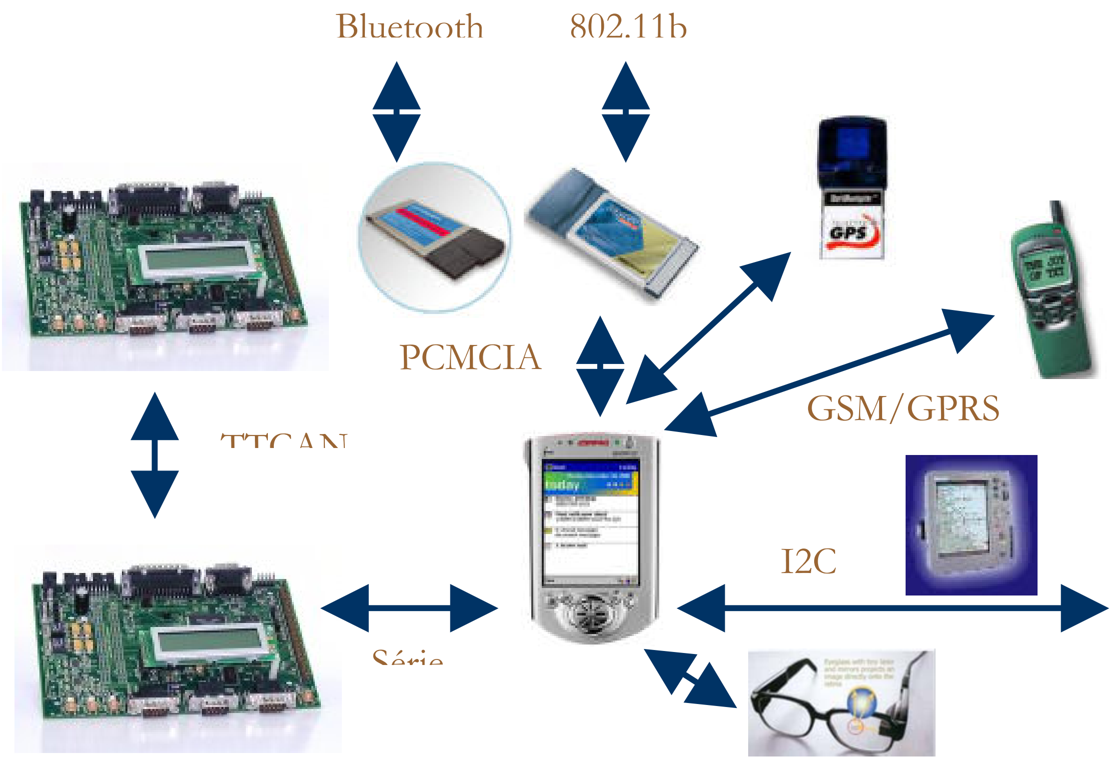


Figure 6: Hardware architecture

Wcomp platform

We have developed the hardware and software core components to get information from the environment. They have been developed as a hardware and software platform to enable connecting different type of components (GPS, compass, temperature devices, etc.) via an I2C bus to a PDA. The device is also connected to a network (local or wide area network) using wireless communication. As explained, this connectivity allows getting data from a central information system, e.g. retrieving relevant data stored in databases, and to interact with learners during the field mission.

Within this framework, the specificity of the man-machine interface results in the replacement of the traditional keyboards and mice by sensors considered as peripherals of the wearable computer. For the moment, the types of sensors which we consider are GPS and a compass but any kind of interesting sensors could be integrated.

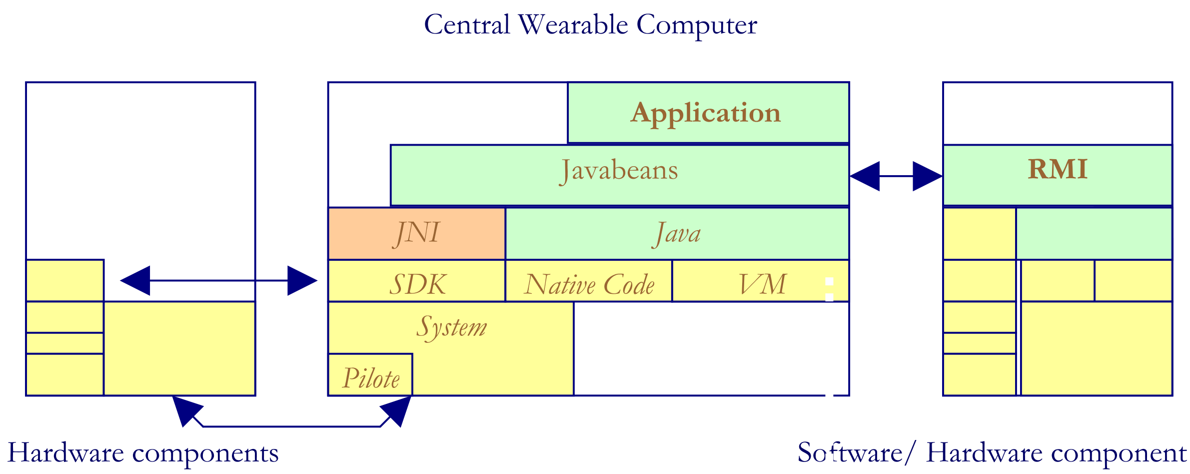


Figure 7: Software architecture of the Wcomp

Multimodality will consist of a tool range of retransmission of the data according to context and user behaviour. For example, an accelerometer located on the end-user makes it possible to know if he is moving. According to this information, the wearable computer will choose the mode of transmission of the services (posting on screen, or vocal retransmission according to the situation). For constraints of stability of the retransmission, one leaves launching of the requests under user control (realized by a pushbutton in our case).

Running examples and experiments

One of the field e-learning applications involves geographical context. In this case, the wearable computer provides services depending on user localization.

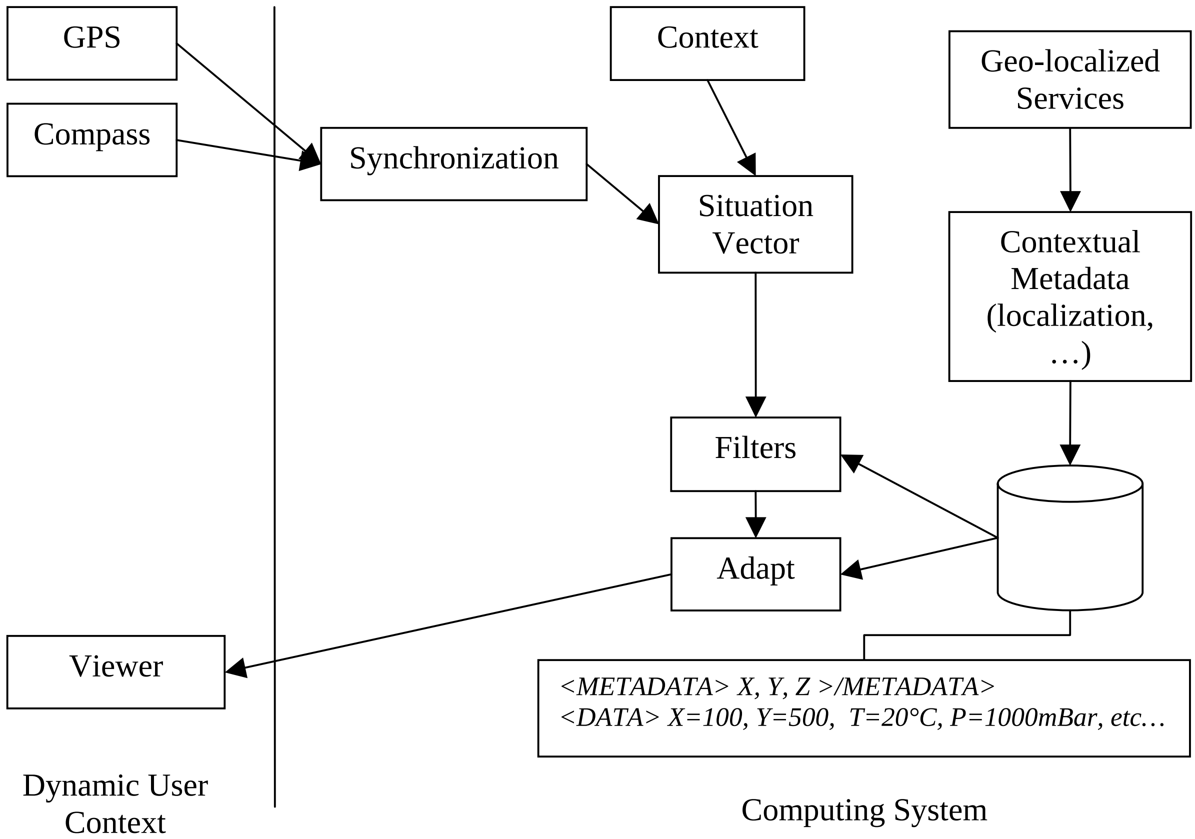
Some examples will illustrate our position. The first is not realized under “real field” conditions. We use this first application to test the system.

A user is exploring a geographical area with a wearable computer as end-user agent. This system is equipped with a GPS and a digital compass to define the global user location (X_u, Y_u, Z_u) and the direction (Θ_u) of what he is looking at. Comparing such information with metadata of available knowledge, the computer can select and deliver relevant, pedagogical and personalised information to the end-user.

Here, we don't take advantage of low bandwidth network connectivity (with GSM/SMS, GPRS for example), but in future work we'll investigate the ability of a distant computer or teacher to dynamically modify the mission of the student.

How does an end-user agent extract user context?

The user context is described using a situation vector with coordinates. Each coordinate corresponds to a value of a sensor measurement at the current time. To avoid instability due to uncontrolled modification of the situation vector, we implement a synchronization mechanism. Thus situation vector keeps a constant value during a minimal sample time. In our running example, GPS provides the three coordinates of the user (X_u, Y_u, Z_u) and the digital compass (Θ_u).



How does an end-user agent select relevant knowledge?

A filter, a type of contextual search engine, explores data in order to select that which will be most relevant for the user. This search will be carried out by comparison between the given metadata and the situation vector provided by the sensors. This data will be returned on the good transmitter, whose choice will be guided by user context, such as his location, but also luminosity, temperature, etc. according to sensors availability.

The filters will send the data, selected among a pre-existent base, to retransmitters. This is the algorithmic part of the project, which consists in implementing information retrieval according to selection criteria. The database stores the contextual metadata and data (a basic kind of pre-existent data, related to the local environment) initially in the form of text, and thereafter any type of data (URL).

The last filter is present to ensure the uniqueness of the relevant data, finally transmitted to the user. We call such filter: an opportunistic filter. Future work could explore the ability to fuse various relevant data.

How does an end-user agent choose the way to layout relevant data?

This is implemented as function of choice of retransmitter, which translates part of the multimodality. For example, a user who is moving will hear information rather than consult them on screen.

Conclusion

This paper first presented requirements for mobile e-learning systems, integrating constraints due to mobility and new challenges in man-machine interfaces. We describe our approach and validate it in a mobile e-learning application.

We still need to add a user profile system to have information about user knowledge. This would allow distributing relevant data depending on user's skills, interests and/or pedagogical "concepts". These first results open the field for other possible extensions. For example:

- fusion of several relevant information (not only a unique one),
- guidance of the user depending on a pedagogical mission (to propose the next area to explore according to pedagogical criteria)
- improvement of data recovery by using dedicated authoring tool to enhance available knowledge stored in database.

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