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Customisation of Learning Paths and Network Optimisation in e-Learning Systems

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1. Introduction

Advanced e-Learning systems must take many factors into consideration, such as functionalities offered to the users, organisation of contents and service fruition modalities. Furthermore, in the presence of multimedia broadband services, network optimisation becomes an essential issue as well.

Talking about functionalities, it is becoming more and more important to involve the user actively, and adapt the studying process and contents to his needs. Not only does such requirement imply a personalised and careful definition of learning paths, but also an efficient choice of assessment phases (Scrivener, 1994; Handy, 1995; Laurillard, 2002).

In this contex, the focus of is on two different viewpoints: (1) the user could desire to choose his own target (*"user-driven customisation of contents"*); (2) the system itself may decide to tailor the learning material on the basis of both the user's background and aims (*"system-driven customisation of contents"*).

As for the user-driven customisation, many e-Learning systems guide the learner by means of an initial test, and consequently define a suitable studying path, but two further variables are taken into account: first, each user is allowed to specify his particular needs and aims; in addition, during the studying phase, he is likely to find or be suggested further related issues. In this case, he should be authorised to redefine his target dynamically.

As far as the system-driven customisation is concerned, when different users face a subject, their backgrounds can be very different, so the system should tailor the kind of material they should be submitted.

The need for such facility is quite evident during conferences, which should be both a way to share new ideas with other experts, and an occasion to keep or become in touch with other subjects, and thus start new collaborations. Difficulties generally arise because the audience's levels of knowledge are very rarely homogeneous and equally specialised. As a consequence, the problem should be faced of preparing people beforehand in a personalised way.

When accessing e-Learning systems, fruition modalities should be as diversified as possible, on the basis of the student's aims, ties and timetables, as well as his location and kind of technologies at his disposal. All such factors must be taken into account in order to reach a good compromise between quality of learning and studying conditions.

This issue is strictly related to network optimisation, where two different concepts are here distinguished: optimising the release of services on the basis of the overall network load and optimising access to contents on the basis of the user's device and access technology.
In the first scenario, in the event of network overload, access to services should be adaptive with respect to the user's needs and connectivity conditions. In particular, since broadband services are often involved, such as videoconferencing and groupware systems, the constant monitoring of the network load is required. In addition, priority applications must be safeguarded, such as real-time on line remote laboratory experiences or examinations. If an overload occurs, such services must be maintained, or at least restored as soon as possible with the necessary quality, and their users privileged.
In the proposed approach, thus, applications are no longer released in a static way, only on the basis of group membership, but are dynamically tailored to the following factors: (1) traffic load detected in the location from where the user has logged on; (2) priority level of critical services currently running on the network; (3) network load along the routes hosting such services.
All such factors allow users of an e-Learning system to be assigned different priority also on the basis of their present activity and to be accordingly safeguarded.
The second scenario is currently under investigation and it concerns the extension of the above architectures to an integrated e/m-Learning environment, where the following guidelines are considered: (i) it is essential to reach the best trade-off among each user's actual needs, quality/quantity of data and response time; (ii) information must be adapted to the user's devices and network access technologies (PDAs, laptops, etc., on UMTS, DSL, WiFi, wired/fiber).
The research activity described in this chapter proceeds from the experiences of the **Teledoc2** project and **Distributed Laboratories** (www.teledoc2.cnit.it/Teledoc2/home.htm), which are briefly described in the following.

2. The Teledoc2 Project and Distributed Laboratories

The Teledoc2 project was financed by the Italian Ministry of Education, Universities and Research (MIUR) and carried out by CNIT (National Inter-University Consortium for Telecommunications). The project was active during 2003-2005 and aimed at building a complete, multimedia, interactive and fully-featured online learning service for ICT researchers and PhD students of Italian Research Centres, provided they were branches of CNIT.
As in many e-Learning systems, the main components were a web-based user interface, the network infrastructure, the e-Learning software and the courses.
Teledoc2 was planned for the diffusion of scientific and technological culture in the ICT field, and meant to allow students to attend specialist courses in the forefront of research. Such courses were at disposal broadcast from different Italian Research Centres.
The project aimed at building an efficient service of distance learning of third generation: the courses could be attended in real-time, just connecting to the CNIT proprietary packet communication network and using simple Personal Computers running a custom multimedia application.
The learning strategy, therefore, aimed at recreating a live virtual classroom environment, with a real-time face-to-face relationship and high levels of interactivity among the users.

Furthermore, the concept of virtual classroom had to be extended to "ubiquitous distributed service", with no kind of limitation to the user's position.
The whole learning system was designed to be complete, efficient, user-friendly and characterized by fixed and suitable QoS levels.
In order to guarantee reliability, CNIT used all its experience in the ICT field both in the backbone connections and in the local ones.
One of the key network requirements was the support of multicast, a strong element of innovation and originality if compared with most of the other distance learning systems. CNIT decided to build multicast-enabled networks because this way of transmission seemed particularly appropriate for online learning services like Teledoc2.
These applications, in fact, required two basic network requirements: on the one hand, they needed one-to-many and many-to-many communications to reach all participants and to promote interaction; on the other hand, they needed high bitrates, since they had to transmit audio and video of fixed quality.
In context of this project, the WiLab (Wireless Communication Laboratories) research unit of CNIT and IEIIT/CNR (Institute of Information, Electronics and Telecommunications - Italian National Research Council) at the University of Bologna carried on further activities.
In particular, the definition, planning and development of the paradigm of "distributed cooperative telemeasure". The "Telemeasurement" concept (meant as remote control of instrumentation belonging to one single workbench) was described in (Roversi et al., 2004), where this methodology was applied to characterize communication systems based on instruments and programmable platforms with Digital Signal Processors (DSP).
The concept of telemeasurement was enhanced with the introduction of "cooperative telemeasurement" (Roversi et al., 2005), in which various resources are distributed in a network of different laboratories and can cooperate to set up augmented experiments. This extension of the telemeasurement concept wanted to increase measurement capabilities, since the user could access different remote laboratories and use remote devices without having all the needed instrumentation locally.The definition and implementation of this platform involved signal processing, management of distributed resources, development of aggregated user interfaces, transport of signals for measure, innovative remote controls, protocols for gaining access and control of specific laboratory instrumentation, prototypes for testing the schemes designed on the field and a proper communication network. As it will be explained in the following, after such activities' completion, research themes evolved into definition and management of contents, access methodologies and network optimization.

3. User-driven Customisation of Learning Paths

In this chapter, an architecture is described for accessing and making use of an e-Learning system whose users can customise their own learning paths and modify them over time.
The discussed approach (De Castro & Toppan, 2008a, De Castro & Toppan, 2008b) is based on adaptive tests and on target redefinition after the completion of a portion of the whole process.
In this approach, the system consists of a three-layered architecture:
(a) *external layer:* access to the system;

(b) *middle layer:* interaction between learner and system, testing module and learning path decision;
(c) *lower layer:* information system and organisation of contents.

These modules have been designed in order to meet the following requirements: (i) according to his interests and purpose, the user can define a personalised target or learning level; moreover, (ii) in case he discovers further interesting issues or deepenings, the e-Learning path can be varied over time accordingly.

The constant interaction among layers allows to adapt learning paths dynamically, and define specific tests which keep the user's improvements under constant check.

Such operations are meant to be tailored to different situations and last the whole lifspan of the learning process itself.

This approach could be of help in many fields, such as Computer-Aided Assessment, which, ranging from automated multiple-choice tests to more sophisticated systems, is becoming increasingly useful. With some of such systems, feedback can be adapted on the basis of both mistakes and actual achievements.

This section is organised as follows: in 3.1, the main architecture is presented. In 3.2, its modules, their role and their interaction are discussed in more detail.

3.1 Main Architecture

The proposed architecture is firstly described with respect to I/O, then to the data flow which takes place over time among the three layers outlined above. The static behaviour of the system is depicted in Fig. 1, whereas the dynamic process is represented in Fig. 2. Each layer will be expanded afterwards in order to discuss its components.

The external layer in Fig. 1 represents the *"User-System Communication Module"*, which acts as an interface between the user and the system.

In more detail, the user chooses a target, which is forwarded to the middle layer. Such block, named *"Testing and Path Decision Module"*, is a front-end between the user and the e-Learning Information System. As a matter of fact, on the basis of the specified target, such module decides the initial test the user must undergo and successively suggests appropriate e-Learning steps.

Both the testing and studying files are stored in the "*Information System Layer"* and are retrieved on the basis of the process above.

Such process continues by means of further assessment phases and suggested steps and, in case the user decides to modify his target, he simply notifies the new information.

In order to better explain how the process evolves over time (Fig. 2), let us define:

- T_i the i-th target defined by the user, T_0 being the initial target;
- L_{ij} the j-th learning level tested during the learning phase whose target is T_i;
- S_{ij} the j-th studying step suggested during the learning phase whose target is T_i

When T_i (i= 0, 1.. n) is forwared from the external layer to the Testing Module, such block accesses the lower layer, retrieves an assessment test appropriate to T_i and proposes it to the user.

On the basis of the test results, a learning level L_{ij} is decided and notified to the Path Decision Module. Such module accesses the Information System and retrieves a learning step S_{ij} appropriate to T_i and L_{ij}.

S_{ij} is finally proposed to the user and the process continues with further testing phases, learning levels definition and steps (j = 1,.. m for each fixed i).

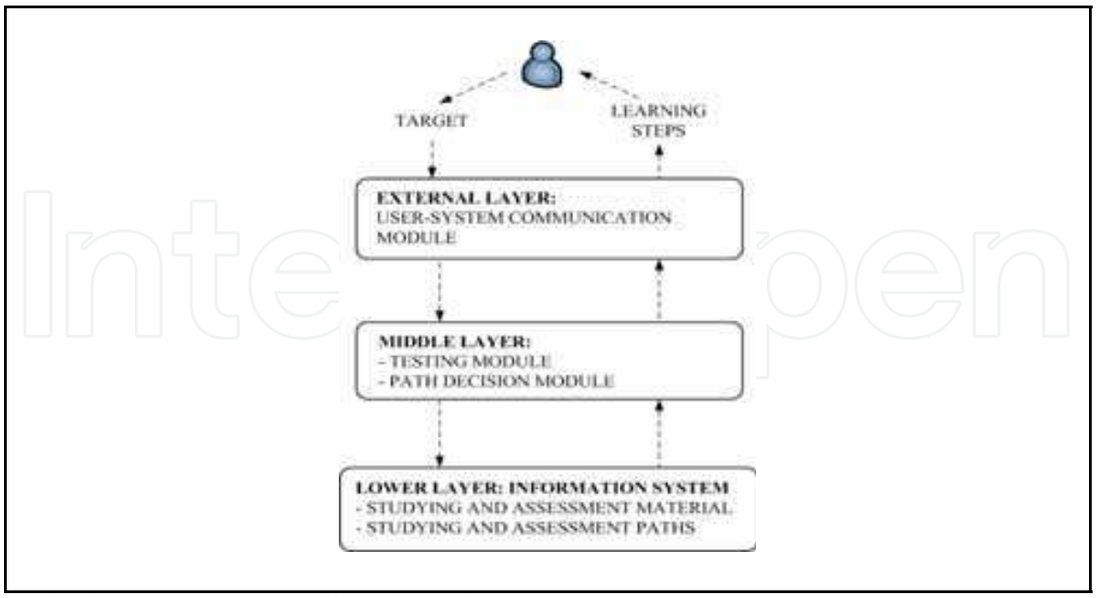

Fig. 1. Main architecture: I/O and data flow

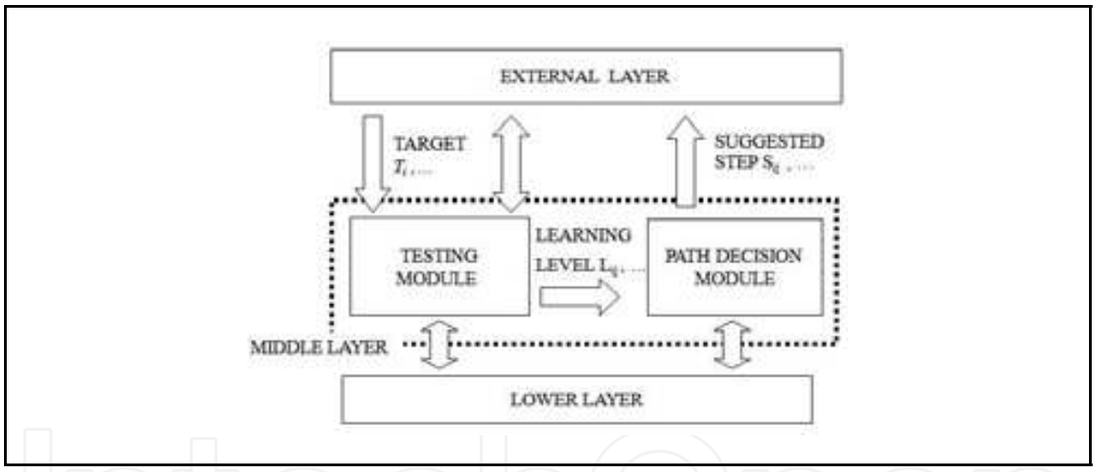

Fig. 2. Main architecture over time

3.2 Main Architecture Expanded

The above architecture is here refined (Fig. 3) and its components discussed separately.

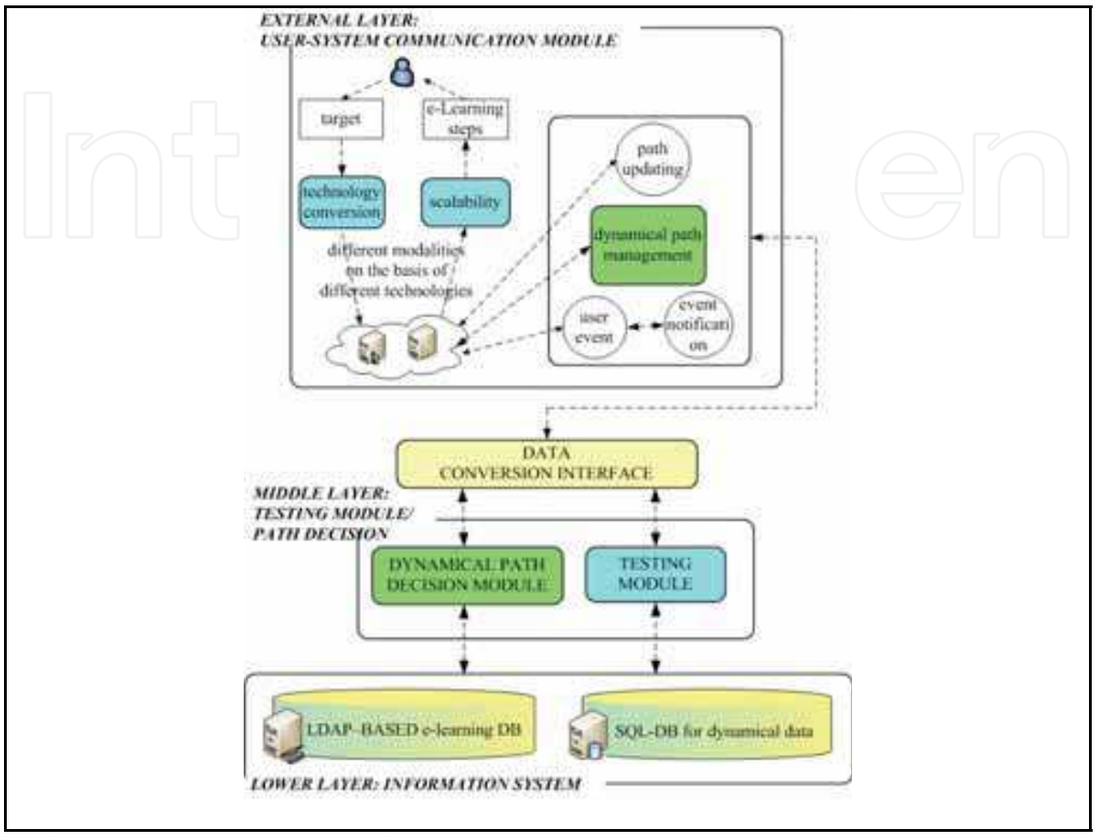

Fig. 3. Main components of each layer

User-System Communication Layer

The User-System Communication Module must carry out the following tasks:

1. receive the user's requests (initial target and successive ones) and trasmit them to the middle layer. All such requests are meant to be events that must be notified to the system;
2. receive the suggested assessment tests from the Testing Module and send back the results;
3. receive the suggested learning steps from the Path Decision Module and allow the user to access the studying material;
4. make the user and the system communicate on the basis of the user's technology;
5. convert user's data in a format that both the front-end (Middle Layer Software) and the Information System can understand.

As for (5), This is meant to be done by means of XML conversions. This conversion will last the whole lifespan of the learning phase (target definition, tests, studying, target redefinition, etc.) and will imply a flow of data among the user, the middle layer and the Information System.

The conversion process is represented by means of the "Data Conversion Interface" module.

Path Decision and Assessment Layer

As discussed in the description of the whole architecture, the main role of the middle layer is to be aware of the user's aims, check his learning levels, and consequently define a tailored studying path.

The main idea is the strict interaction between the Path Decision/Assessment Layer and the Information System. As a matter of fact, the database stores both assessment and studying material which is selected from the database on the basis of the user's goals and actual achievements.

The database schema will be better discussed further on, but, in order to describe the process, it is here briefly summed up.

Its contents can be represented by means of a network of *issues*, *levels* and *prerequisites*. Consider issues I_l and I_m and suppose they are related (such as derivatives and integrals) and meant to be faced at a given level (such as a course of Mathematics at a high school).

For the sake of simplicity, suppose I_l and I_m can be considered steps of the learning process.

Suppose that facing step I_m after step I_l requires prerequisites p_1, p_2, ..p_k.

This kind of algorithm can be represented by means of a Petri Net which acts as a traffic light between a learning step and the successive one (Chen et al., 2001; Li et al., 2005).

In this approach, the Petri Net's places are knowledge to be tested (prerequisites), and its transitions are studying phases. A transition is enabled if all the required prerequisites have been fulfilled.

In other words, the architecture in Fig. 2 hides a cycle that guides the assessment phase and the possibility or not to proceed to further steps.

Information System Layer: why LDAP/SQL

As far as the underlying e-Learning information system is concerned, its architecture has been designed keeping in mind that two kinds of information are involved:

(i) e-Learning and assessment material, which is not meant to be frequently updated (named *static data*);

(ii) personalised learning paths and assessment results, which are time-varying (named *dynamic data*);

It must also be noticed, and considered as a requisite, that e-learning information can be represented by means of a hierarchy of subclasses. For instance, from a subject to its specific issues.

These requirements suggest the use of a hybrid database structure for data storage: an LDAP directory service (Howes et al., 2003) for static data and a relational DBMS for dynamic information.

LDAP means Lightweight Directory Access Protocol and it is used for accessing directory services; it runs over TCP/IP or connection-oriented transfer services.

LDAP provides both a model and an implementation tool which is particularly suitable for web-based e-Learning applications, both from the data representation viewpoint and for an efficient web-based access.

As a matter of fact, it is scalable, extendable and optimised for reading operations, so it is particularly suitable for static data. It also supports standards and interfaces of many multimedia broadband applications and integrated access to e-Learning services.

Another important feature is that LDAP represents information by means of a hierarchy of classes using very flexible schemata. In the considered environment, this implies at least three advantages.

First, the knowledge that a person acquires on a specific subject can be organized in an LDAP tree as follows: the n^{th}-level class describes the *subject* in general; the n^{th+1}-level classes represent related subjects, issues and related issues, documentation and assessment material, prerequisites, learning paths and assessment tests.
Learning and testing material, as well as paths and tests, are divided in as many subclasses as the number of target levels provided for. In this way, known such level, the middle layer can access the correct material.
As a consequence, this schema allows to represent studying information according to a network-like model of a subject, its topics, relationships, etc.
As for the second advantage, LDAP was built for the integration of distributed environments, so it also suits the distributed location of documentation very well. As a matter of fact, for applications such as international remote education, e-Learning information is distributed by nature.
The third advantage concerns schema management. The schema of the e-Learning database is likely to be modified or augmented during its life cycle, for instance due to the addition of new kind of media or information described by means of different properties. A relational system, in traditional settings, does not allow efficient schema revision. Such operations involve high costs in terms of redesigning existent schemata, reloading data and verifying that original constraints and relationships on data are preserved. LDAP, on the contrary, offers high flexibility in modifying data structures.
As far as the dynamic part of the database is concerned, it mainly concerns the time-varying personalised learning paths. In more detail, the dynamic database stores information about the user and his learning phases, such as targets, suggested steps and actual achievements.
In this case, an SQL database is more suitable. As a matter of fact, such models are optimised for reading/writing operations and time-varying data.
The connection between the LDAP and the SQL databases are LDAP object identifiers which, as identifiers of subjects, issues, etc., are used as key information in the definition of dynamical paths and assessment tests results. They are also used in the joint navigation of LDAP and SQL data.
In this context, the features of LDAP were briefly explained. In the following section, a complete LDAP schema will be defined.

4. System-driven Customisation of Learning Paths

In this chapter, the situation is considered where users who access the e-Learning system have very different backgrounds and want or should cooperate. This problem is particularly evident during conferences, which are becoming more and more complex, articulated and divided among different topics.
Very rarely is it possible to face every specific topic available, thus the problem arises of preparing people beforehand, so that they can actively take part in presentations, discussions and so on.
Some problems and schemes are here discussed for lining different competences up with the specific topics of a conference session.
The whole method proposed (De Castro & Toppan, 2007a) is again based on a 3-layered structured architecture, completely different from the one in Section 3. This architecture leads from the specific person to the prerequisites he needs in order to approach a subject

and consists of the following steps: classification of people on the basis of their level of knowledge (4.1); definition of a method for deciding a personalised background (4.2); definition of a knowledge base for e-Learning which must be both flexible and easily accessible through the web (4.3).

4.1 Levels of Knowledge (External Layer)

First of all, let us consider a specific sub-area and its topics. With respect to these, the audience of a conference is generally composed of three main kinds of people: (i) those who are expert in that theme and topics; (ii) those who are involved in the same theme but with different specialized knowledge, and (iii) those who, due to the interdisciplinary nature of most modern research fields, are in touch with such subjects even though they are not directly their own. In other words, knowledge of the many different topics is very rarely homogeneous and equally specialised.

This scheme is depicted in Fig. 4: Fig. 4a shows a very simple, typical classification of the conference's main theme into sub-areas and specific topics within each sub-area. For the sake of simplicity, the links among different topics are hidden. Fig. 4b shows the different positions, meant as levels of knowledge, of the three types of people described above with respect to the blocks in Fig. 4a.

A conference is also meant to be a meeting and an occasion to share knowledge and discuss new possible developments. According to such view, two further aspects must be taken into account: the hyper-specialised knowledge and the knowledge arising from interdisciplinary work. In both cases, entering other subjects in some level of detail would, in all probability, give raise to new ideas and cooperation (Fig. 5).

As a consequence, not only should a conference allow experts in a specific field present and share their new results and enhancements, but it should also help people from other specific fields or from different research areas approach or keep in touch with subjects which are related to theirs.

In order to achieve such result, it is necessary to find a way for giving people a proper background on the desired subjects or topics.

4.2 Tailoring e-Learning Paths (Middle Layer)

In order to provide each participant with a proper background on a desired subject, the proposed approach is divided in two phases: the first aims at identifying which level of knowledge a person has on a specific theme or topic, the second consists of tailoring the background material to such level.

Since the levels of knowledge in a single sub-area and its topics can vary a lot, a distinction is made among the three types of people described in the previous chapter. They can be:

[1] specialised in the considered theme: in this case, no background material should be provided

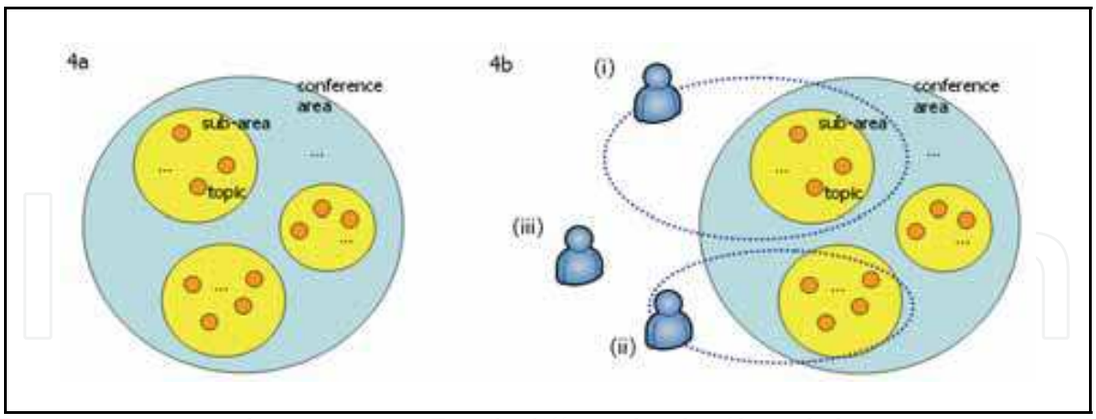

Fig. 4a. main area, sub-areas, topics; Fig. 4b: different levels of knowledge

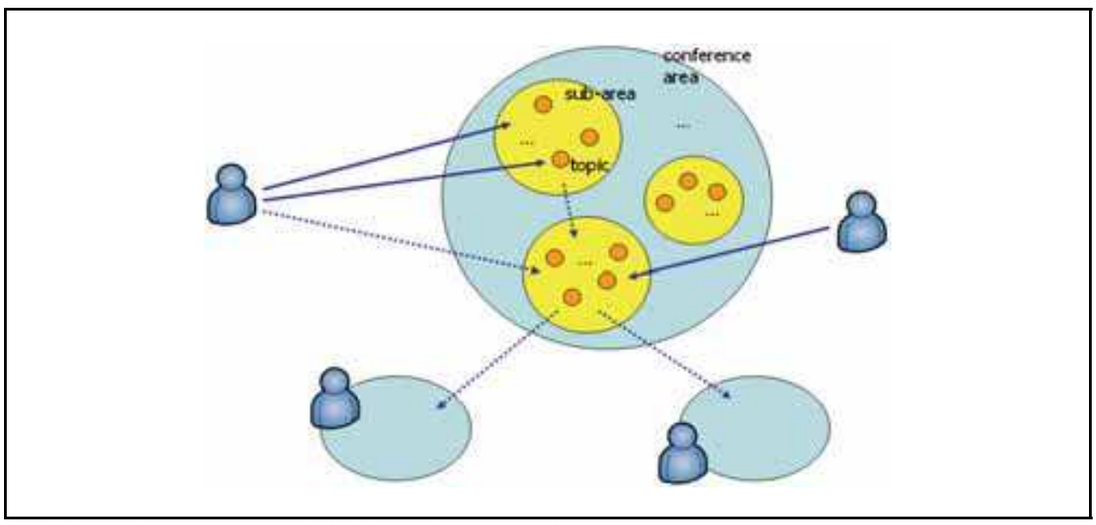

Fig. 5. broadening research fields and cooperation

[2] specialised in other, related themes: in this case, specialised background material should be provided

[3] not specialised in the field: in this case, basic background material should be provided

As far as the problem of deciding the level of knowledge is concerned, in this approach it can be determined either *statically* or *dynamically*.

In the first case, the person is simply interviewed via a simple form which lists the themes and the topics and he/she decides those he wants to deepen. A *static knowledge path* is thus provided, which can consist of technical material on current results for expert people and introductory material for the non-experts.

In case of dynamically defined knowledge level, the person is shown the possible connections between his/her activity and the available topics, and a possible way is thus suggested to broaden his/her competences (*dynamic knowledge path* or *tailored knowledge path*).

One of the main problems is on whom the responsibility of preparing such paths should rely upon. On the one hand, static knowledge paths can be (more or less) easily organised by collecting background and technical information about each theme and each single topic and make it available to whom requires it.
As far as dynamic knowledge paths are concerned, the problem is far more difficult and demanding.
As a matter of fact, it requires the analysis of different knowledge areas and specific topics with respect to the person's competences (Fig. 6).
Defining these paths would require an enormous work and a very broad, deep and far-sighted competence in many research areas, and some main common outlines should be decided.

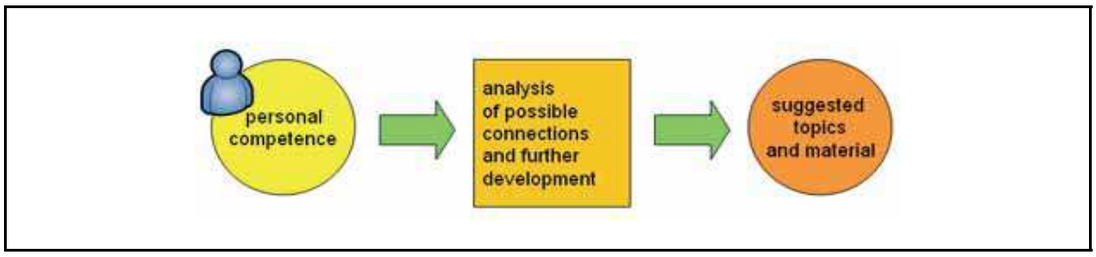

Fig. 6. a dynamically decided knowledge path

A possible trade-off could be the following: the organisers could require the background of people and their research interests. These curricula should be classified and inserted in some main groups.
Specific tailored paths for each group should thus be outlined by some experts from different disciplines.

4.3 The e-Learning Architecture (Lower, Internal Layer)

As far as the underlying *e-Learning information system* is concerned, it based on an LDAP architecture as in the previous section, due to the same motivations. Again, the background information is represented according to a network-like model of a subject, its topics and the relationships with other subjects and themes.
The LDAP schema design methodology is now briefly summed up [www.openldap.org, www.prasannatech.com/ldapdesign.html] and the proposed schema described afterwards.
LDAP means Lightweight Directory Access Protocol and it is used for accessing directory services; it runs over TCP/IP or connection-oriented transfer services.
The LDAP data model is an object-oriented one and it is based on entries, distributed on a tree. Entries have set of attributes, single or multi-valued, are identified by a Distinguished Name (DN) and their schema is described by object classes.
The definition of a new LDAP schema must obey the following rules:

1. obtain Object Identifiers
2. define custom attribute types
3. define custom object classes

Each schema element is identified by a globally unique Object Identifier (OID). OIDs are also used to identify other objects. They are commonly found in protocols described by ASN.1. In particular, they are heavily used by the Simple Network Management Protocol

(SNMP). As OIDs are hierarchical, an organization can obtain one OID and branch it as needed. For example, if an organization is assigned OID 1.1, the tree can be branched as shown in Tab. 1:

OID	**assignment**
1.1	Organization's OID
1.1.1	SNMP Elements
1.1.2	LDAP Elements
1.1.2.1	AttributeTypes
1.1.2.1.1	myAttribute
1.1.2.2	ObjectClasses
1.1.2.2.1	myObjectClass

Table 1. Example of OID hierarchy

OIDs can be asked and registered at the Internet Assigned Numbers Authority (IANA, www.iana.org/cgi-bin/enterprise.pl).
With respect to system-driven customization of learning paths and to knowledge in general, the knowledge that a person acquires on a specific subject can be organized in an LDAP tree as shown in Fig. 7: the 0-level class describes the *subject* in general; the 1-level classes represent respectively the *source documentation*, the *produced documentation*, the *non-documented material*, expert *people* found during the learning and communicating process and some *related subjects*. The legend of classes and attributes is detailed in Tab. 2 and describes the only attributes whose semantics can be ambiguous. It must be noticed that the multi-valued attributes *contacts* and *links* keep track of the links among documentation, authors and experts, related subjects and so on.
Even though many other types of classifications have been made and are available on the Internet, the aim of this proposal is to define a possible common structure for web-based bibliographies.
With respect to the OID hierarchy in Tab. 1, class subject can be assigned OID 1.1.2.2.1; the 1-level classes are respectively 1.1.2.2.1.1, 1.1.2.2.2,…, 1.1.2.2.5. The same applies to the attributes.

4.4 Representation of the Whole Process

Let us now synthetize the whole web-based process by means of an UML-like diagram (Fig. 8). A person requires some background on a certain topic or subject, together ; his request is forwarded to the *path decision module* through a web server and his knowledge level analysed. The appropriate tailored knowledge path is then decided and the user can finally access the background material trough the web-system.

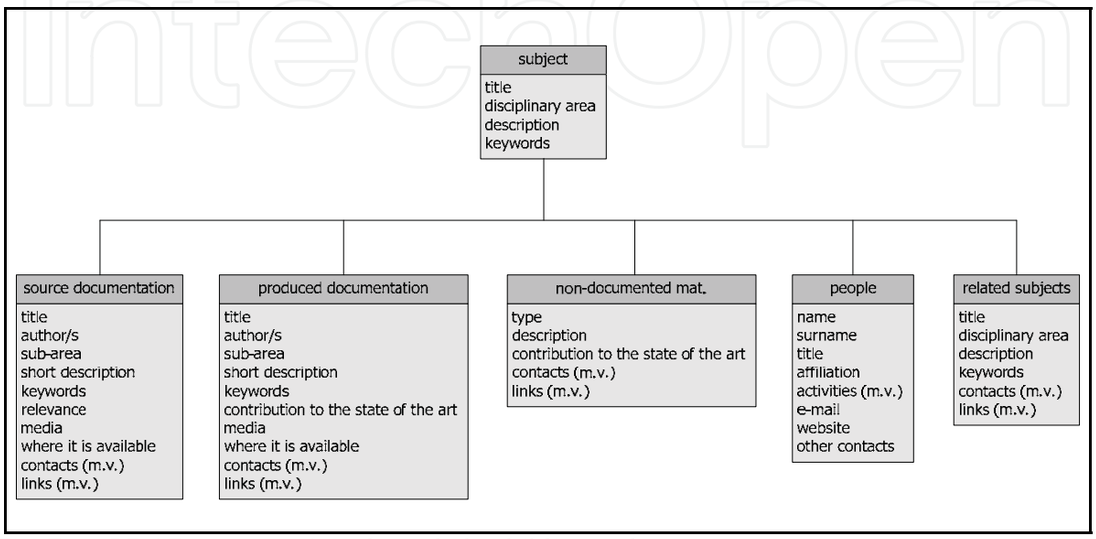

Fig. 7. an LDAP structure for a knowledge bibliography

class	**attributes**	**description**
subject	title, disciplinary area, description, keywords	
source documentation	title, author/s, sub-area short description, keywords, relevance media where it is available contacts (multivalued) links (multivalued)	 specific area within the subject personal opinion of the person on the material type of document and store: video-conference stored on a dvd, etc. url, private archive, etc. people related or cited suggested and other related links
produced	title, author/s,	

documentation	sub-area short description, keywords, contribution to the state of the art media, where it is available, contacts (multivalued), links (multivalued)	as above personal opinion of the person on his own contribution as above
non-documented-material	type description, contribution to the state of the art, contacts (multivalued) , links (multivalued)	note, ideas, informal talks, drawings, etc. as above
people	name, surname, title, affiliation, activities (multivalued), e-mail, websites, other contacts	specific interests in the subject
related subjects	title, disciplinary area, description keywords contacts (multivalued) links (multivalued)	 people related or cited sites referring to related subjects

Table 2. Classes and attributes of the LDAP-based bibliography

5. Network Optimisation in e-Learning Systems

Modern e-Learning systems involve broadband services and critical applications as well, such as teleconferencing for on line laboratory experiments or examinations. In the event of network overload, these services must be maintained, or at least restored as soon as possible with the necessary quality (Bronson et al., 1993; Yuang et al., 1994; Caouras et al., 2003).
In this context, a kind of network optimisation is discussed, based on the adaptive release of services on the basis of their urgency and need to be safeguarded (De Castro & Toppan, 2007b).
Managing broadband services requires the constant monitoring of network load, especially when critical applications are involved. Many robust solutions exist, based on flow prioritisation or dedicated connections. An alternative solution is here proposed, which can not be applied to whatever network topology or to very high-risk applications, but is effective and less expensive than traditional methods. This approach is addressed to LANs connected through the Internet, with a federated network authentication, and hosting medium priority services, as it happens in case of the e-Learning system of a campus.
In case the necessary bandwidth is not available, priority applications are guaranteed to run regularly by limiting non critical services to some clients.
As a consequence, users must be aware of this kind of management, since a strong control is wielded on both their PCs and activities.

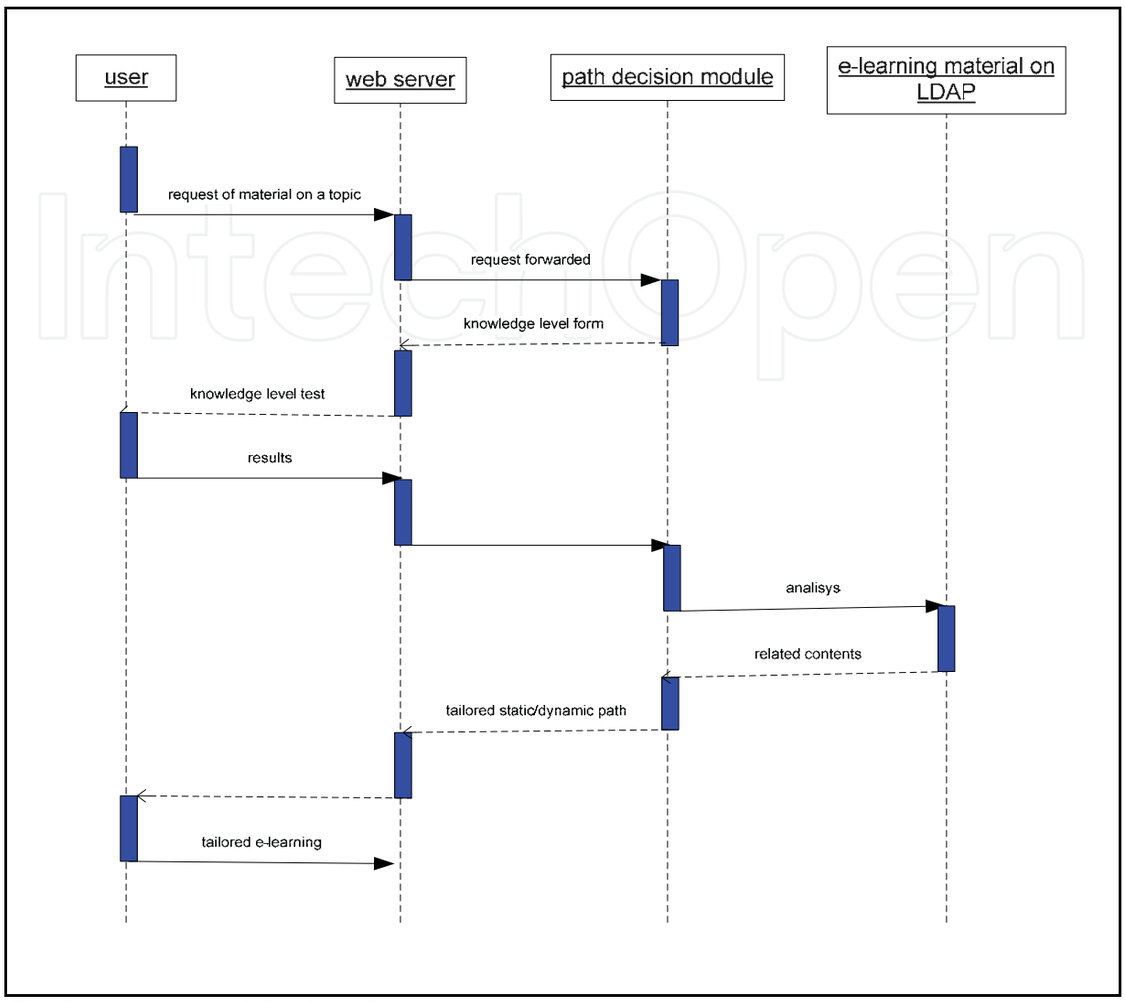

Fig. 8. interaction of the three layers

In more detail, applications are no longer released in a static way, only on the basis of group membership, but are dynamically tailored to the following factors: (1) traffic load detected in the location from where the user has logged on; (2) priority level of critical services currently running on the network; (3) network load along the routes hosting such services.

5.1 The first Approach to Adaptive Release of Services: "Software Emergency"

This kind of adaptive release of applications on the basis of external conditions was partially designed in a completely different context, (www.insebala.com). Although Software Emergency has been extended and completely redesigned, it worths being summarised and compared to the new architecture (Donzelli et al., 2006).

In a few words, Software Emergency performs regular network load controls and, in case problems occur in a given area, releases bandwidth by limiting services to those clients who have lower access rights. For instance, consider a network administrator and a guest user. If no trouble is detected, they will both be able to use messaging, VoIP and videoconferencing.

In case a network emergency takes place, the guest will be allowed to use the only messaging service, so that the administrator will be provided with the largest bandwidth possible.
It must be noticed that this approach requires the whole network topology to be known, since each link has to be monitored, and each client has to be simulated and evaluated.
The whole schema is depicted in Fig. 9 and is based on: (1) a hybrid LDAP/SQL information system [9] which stores each user's credentials, group membership and rights at different critical conditions; (2) network load measurements and corresponding real-time simulation of the network; (3) a method for determining the user's location through his IP; (4) a unit named *"Emergency Decision Module"* (EDM), which, on the basis of the client's IP and the measurements above, determines the *"emergency level"*; (5) the "Emergency Controller" and a client module named "Local Emergency Controller" (LEC).
In this environment, access rights depend on three factors: user's identity (dn, *Distinguished Name*, the LDAP identifier) and consequently his group membership and location.
Such rights vary at different critical conditions and are represented through as many LDAP subclasses as the possible values of the emergency level (fixed range: 0-99). Each subclass stores Access Control Lists (ACLs), whose attributes are *(can, who, what)*. The ACLs of each subclass, i.e. of each emergency level, indicate which services (*what*) are available (*can*) to which groups (*who*).
In case the available bandwidth goes under a given threshold, the emergency level is varied, users' access rights are accordingly refreshed and each client is notified of which applications are still at his disposal. For instance, consider two areas with different load conditions. A user can be allowed to use videoconferencing if he logs on in the first area and be prevented from using it in the other.

5.2 Dealing with medium-priority Applications

The main difference between Software Emergency and the new architecture lies in how access rights are defined and managed if critical services are required.
In the previous approach, each user's access rights depended on his location and group membership, were fixed at each emergency level, and varied when such level was modified.
In the new approach, each user's access rights no longer depend on such factors only, but also on priority of applications currently running on the network. Furthermore, such priority can vary over time.
Consider for instance a professor who is currently giving lectures through videoconferencing and some students downloading bibliography. If an overload occurs, the students' activities will be blocked and the professor privileged, since the priority of his current activity is higher. If the same professor is using videoconference in low-priority mode (for instance when contacting a friend), in case network troubles arise, he will lose the service himself.
In more detail, every time a user demands a precise application, he must specify its purpose and a given time interval, (e.g.: videoconference for tele-lecturing from 9 a.m. to 11 a.m.). In this way, the system will associate such service to a "priority level". Besides the ordinary Software Emergency management, the system must deal with the following situation: in the presence of a priority application, particular attention must be paid to overload controls in the corresponding network route and, consequently, all the clients using links of such route must be informed about which services are currently available. In other words, the

management of priority runs in parallel to Software Emergency and can force stronger conditions and controls.

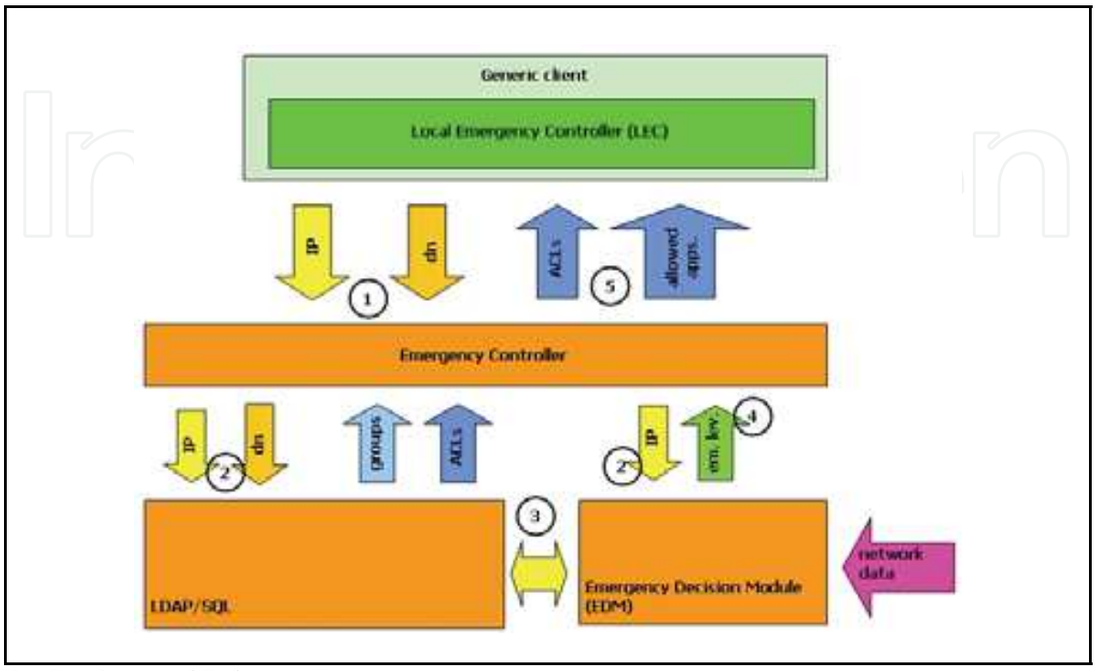

Fig. 9. schema of Software Emergency

Input = user's IP and dn, network load measurements; output = services allowed to the user in his current location

Taking all these factors into consideration, the architecture was modified. In particular, the following modules were redesigned: the LDAP/SQL information system, network representation and scheduling plans included; data flow among clients and the system, modalities of service management during critical situations.

5.3 Architecture

A fundamental prerequisite of the considered environment is that the network can be represented by means of autonomous areas whose main links' state and available bandwidth can be measured through snmp queries. This implies that network paths included in the network kept under control can be determined. In particular, each client can determine the network path he is currently using.

This allows to represent network topology, load measurements and critical applications'data in the LDAP/SQL information system.

The network is represented by means of the set of its links and the corresponding available bandwidth (as in Software Emergency). Furthermore, in order to represent critical services, the following data become an integrant part of each link's description: (1) *priority level* of applications currently using the link; (2) their *end time*; (3) *minimal bandwidth required* for a proper release of the priority service; (4) *tolerance*, meaning the longest period of time such service can undergo a malfunction. The new architecture works as represented in Fig. 10.

The core of the whole system is a middleware layer named *"Priority service" (PS),* set between the network and clients' access to services. Besides the main modules of the previous architecture, it contains two further blocks, named "Priority Scheduler" and "Priority Engine", the network and clients' access to services, respectively. With respect to the Software Emergency architecture, not only have these modules been added, but the whole process is different, too.

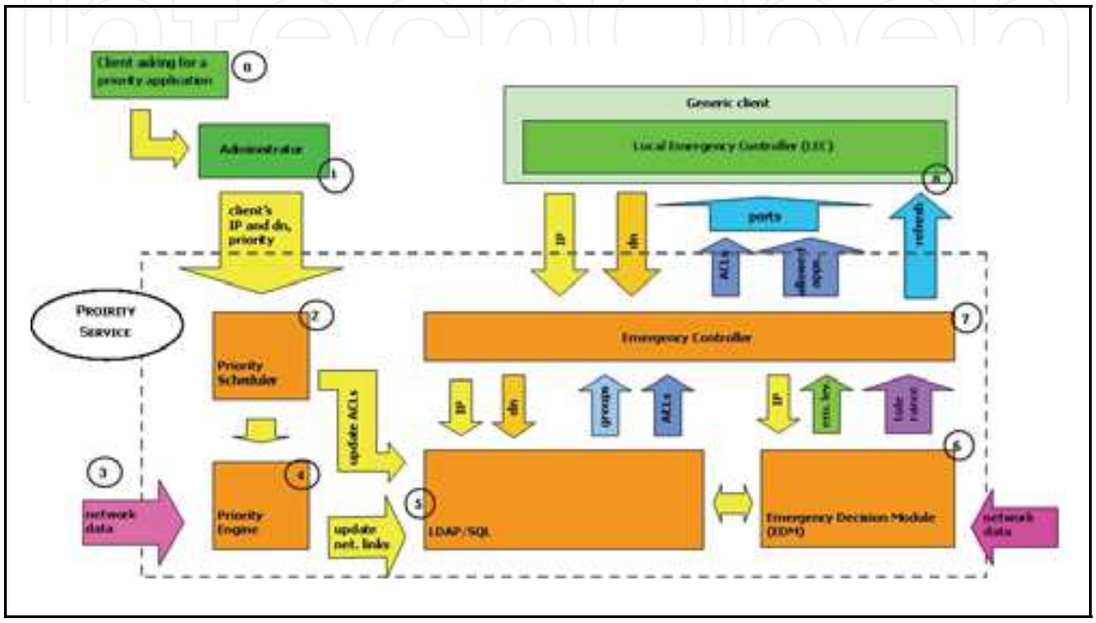

Fig. 10. main architecture for the management of high-priority applications

When a client needs a priority service (steps 0-5 in Fig. 10), the administrator forwards the following data to the "Priority Scheduler": (a) user's dn and IP, (b) priority level, (c) end time, (d) minimal bandwidth required, (e) tolerance time. This module activates the "Priority Engine" for the whole duration of the critical application and forwards such data to the LDAP/SQL block. In this way, ACLs can be appropriately modified.
The IP of the user who is running the critical service is forwarded to the Priority Engine and so is the route such client is using (and has determined). The Priority Engine controls the corresponding links so frequently as the tolerance time ("*refresh time*") indicates. On the basis of such controls, the engine updates both application's data and available bandwidth.
Software Emergency and the Priority Engine work in parallel. The former checks the whole network load on the basis of a hierarchy of routers classified on the basis of their importance. The latter – for the whole duration of the service - controls the routes and updates the measurements on the corresponding links.
As far as the emergency level is concerned, it is determined as follows: when a critical application is active, each link of the route above has both the "available bandwidth" and "minimal bandwidth required" fields. The former being lower than the latter gives raise to an emergency situation. Both the EDM and the Priority Engine update the database, so the emergency level is defined concurrently (steps 5, 6 in Fig. 10).

As far as the release of services to other users is concerned, each generic client is provided with the "Local Emergency Controller", which is implemented through a firewall. Every refresh time, the controller obtains the list of the ports allowed for network traffic. In particular, it sends both its IP and dn to the Emergency Controller, which forwards such data to the EDM and LDAP/SQL block. The EDM determines the corresponding emergency level as explained above, and provides the client with information about available ports.

5.4 Towards an integrated e/m-Learning Environment

The above scenario describes a kind of optimisation of services release with respect to the overall bandwidth available. Another kind of optimisation concerns each single user: given a bandwidth, access to services can be optimised by means of a proper release of contents.
In other words, the following guidelines must also be taken into account: (i) it is essential to reach the best trade-off among the user's actual needs, quality/quantity of data and response time; (ii) information must be adapted to available technologies (PDAs versus laptops, etc.). In other words, the system ought to be queried the required data in a proper format.
Developing such a system involves at least two aspects: first, information must be represented at different levels using different formats. Second, an access methodology must be designed for filtering data on the basis of criteria (i) and (ii).
For instance, if a student is using a PDA with an UMTS technology and wants to access an on line videoconference in real time, he must be aware that he had better abandon the video and only listen to the audio. The same applies to many contents, ranging from real time lessons to access to the e-learning database: in order to optimise access to services, the proper technology and the proper amount and format of information must be chosen carefully.

6. Conclusion

This chapter dealt with three different subjects: first, a three-layered architecture was discussed for an e-learning system where the user is allowed to specify his goal and redefine it during the learning process. The proposed architecture is based on an LDAP-SQL information system which interacts with an assessment and path decision module. Such block suggests appropriate steps, retrieved from the database, on the basis of the user's actual achievements. As for the second subject faced, some early architectures and methods were presented for providing an appropriate background to the participants to a conference. Some early guidelines were stated for defining tailored backgrounds allowing a person to approach a new topic within his subject or a new one. Finally, a particular kind of network optimisation was presented, based on the selective release of services in case of network overload or specific needs of critical applications. This architecture is currently being tested on a highly hybrid LAN at WiLab (University of Bologna, Italy).
Further work will be devoted to deepening the proposed architecture, to the completion of all the system modules and to the design of a mathematical model for understanding the possible effects of the proposed approaches on a large-scale hybrid network.

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The widespread deployment and use of Information Technologies (IT) has paved the way for change in many fields of our societies. The Internet, mobile computing, social networks and many other advances in human communications have become essential to promote and boost education, technology and industry. On the education side, the new challenges related with the integration of IT technologies into all aspects of learning require revising the traditional educational paradigms that have prevailed for the last centuries. Additionally, the globalization of education and student mobility requirements are favoring a fluid interchange of tools, methodologies and evaluation strategies, which promote innovation at an accelerated pace. Curricular revisions are also taking place to achieved a more specialized education that is able to responds to the society's requirements in terms of professional training. In this process, guaranteeing quality has also become a critical issue. On the industrial and technological side, the focus on ecological developments is essential to achieve a sustainable degree of prosperity, and all efforts to promote greener societies are welcome. In this book we gather knowledge and experiences of different authors on all these topics, hoping to offer the reader a wider view of the revolution taking place within and without our educational centers. In summary, we believe that this book makes an important contribution to the fields of education and technology in these times of great change, offering a mean for experts in the different areas to share valuable experiences and points of view that we hope are enriching to the reader. Enjoy the book!

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