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ABSTRACT

As yet, there are no specialists in the application of information technology to education and training. However, this is one of the fastest growing areas on the Internet due to the recent perception of the enormous potential for the use of Web resources for this purpose. This has attracted the attention of researchers in industry and the academic world who are currently developing various models and products for Web-based education and training. In this paper, AulaNet is presented, an environment for the creation and maintenance of Web-based courses designed for the layman. Resources for the implementation of the conceptual framework are described, and AulaNet is also compared to other similar Web-based environments. (Contains 34 references.) (Author/YDS)

AulaNet™ - An Environment for the Development and Maintenance of Courses on the Web

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Abstract

As yet there are no specialists in the application of information technology to education and training. However, this is one of the fastest growing areas on the Internet, due to the recent perception of the enormous potential for the use of Web resources for this purpose. This potentiality has attracted the attention of researchers in industry and the academic world, who are currently developing various models and products for Web-based education and training. In this paper we present AulaNet™, an environment for the creation and maintenance of Web-based courses designed for the layman. We also compare AulaNet™ to other similar Web-based environments.

Keywords

Web-based Education, learningware, software, information technology

1. Motivation

From the technological point of view, the first motivating factor that led the LES to teaching/learning based on the Web (Web-based Education [1]) is linked to the great transformations that Web technology has brought to the process of software development and to the actual concept of software. More and more often developing software means developing a Web-based solution. Therefore, it is becoming essential that research into Software Engineering investigates models, languages and tools for the specification and development of Web-based software.

Studying software technology independently of application domains, for which one could, for example, develop real case studies, often leads to very general models, languages and tools that are inappropriate for the majority of practical situations. Whereas the study of technologies in the ambit of a specific domain does not restrict the discovery of methods and tools that could be used for general purpose. From the methodological point of view the LES chose to dominate Web-based solutions focusing on the use of the Web in the area of education.

Another reason why the LES was motivated to research Web-based education and training is that this area offers vast potential for universities to cooperate with industry and society in general. Furthermore, the clear emergence of an Information Society, with global characteristics, has enormously stimulated industry's interest in education and training as a way of ensuring competitiveness.

International Data Corporation [1] believes that the adoption of education and training based on the Web, either through corporate Intranets or through the Internet, barely started in the second semester of 1997 and will explode into a 2 billion dollar market in the year 2000. The main driving factor for Web-based training is the necessity to find methods of bringing training directly to the desktop in a continuous just-in-time way.

In the sections that follow we present the characteristics of the teaching/learning process based on the Web, an emerging model for environments for the development of Web-based courses called AulaNet™. We also give a description of AulaNet™'s environment, and its implementation, and we make a comparison of it with other systems. Finally, we present our conclusions and the results we believe will be achieved in the future.

2. Characteristics of the Teaching and Learning Process Based on the Web

IDC [1] proposes classifying the Web servers used for education and training. On the one hand there are the campus style servers: that facilitate Web-based education and use multiple technologies (interactive multimedia content, interaction with instructors and between students, chats and so on). On the Internet 2 project this technology is being called "learningware" [2].

On the other hand, there are servers that offer multimedia courses projected and developed through a unique technology (a title based on a specific technology, for example: authorware, that uses the technique of Instructional Design). In this case the Web site substitutes the CD as a medium to offer courseware.

The constructivist movement (eg: Papert [3, 4]) and new communication technologies (Wilson [5]) challenged this concept suggesting that this is not the only way to support apprenticeship. More and more often, people are learning without the help of Instructional Design. In various circumstances natural apprenticeship is more efficient than apprenticeship based on Instructional Design [6].

We need to understand how established instruction systems (eg: classrooms) can migrate to a more open organization, in which part of the lecture could perhaps be given according to the "dynamic community model for apprenticeship".

A learning process, at any level of instruction and training, normally incorporates the following actions [2]: (a) Establishing the objectives of the learning process; (b) Finding and revising (or creating) instructional material; (c) Assessing students' level of knowledge; (d) Assigning appropriate material to students; (e) Defining the form of access students have to components/modules; (f) Revising and following-up students' progress and intervening when necessary; (g) Providing and managing communication between student and instructor and between students themselves (synchronous as well as asychronous); (h) Assessing the learning process and (i) Preparing reports of the results of the learning process.

We began working on the AulaNet™ project in the LES in June 1997. Instructors from three disciplines were invited to specify the support tools they would need to develop the learning process they would use in their courses during the second semester of 1997. The three courses were: Introduction to Science and Computer Science [7]; Information Society [8] and Heat Transference [9].

Based on the availability of tools tested by the LES the year before the project was launched, the following preliminary check-list was proposed: (a) Publication of the text book as hypertext; (b) Publication of texts associated to the lectures; (c) Recording lectures with the instructor present; (d) Online transmission of lectures with the instructor present; (e) Publication of students projects; (f) Forms of assessing students (exams, etc.); (g) Use of slides + description of slides; (h) Interactivity on the Internet; (i) Use of News; (j) Form of online support to the organization of the Course; (k) Students as information providers; (l) Use of animation, video etc; (m) Use of software by the students; (n) Lectures in the laboratory and (o) Definition of Development of the Learning Process.

3. A Conceptual Framework for Applying Technology to Education

The environment provided by AulaNet™ aims to reflect a conceptual framework for the implementation of technological innovations in education. This is based on three arguments:

- Adoption precedes change. So that any intended change can take place the innovation must be adopted by the students and instructors first;
- Creation is re-creation. The process of implementing a new innovation is, essentially, a process of re-creation in which instructors and students reinterpret the innovation in their own terms. In this way the production of a new innovation frequently reflects a set of solutions of compromise between the new and old way of doing things.
- Apprenticeship is the evolution of knowledge. Human beings are active, but fallible, creators of knowledge. The knowledge created must be improved by the criticism of their peers.

Therefore, the objectives of AulaNet™ are: (a) to promote the adoption of the Web as an educational environment; (b) to contribute to pedagogic changes, giving support to re-creation and (c) to encourage the evolution of knowledge (as much for the students as well as for the instructors).

To implement these objectives the following resources were foreseen for the AulaNet™ environment:

(i) **Total integration**: AulaNet™ will have a set of tools for students and instructors designed for the various stages of the learning process. An integrated environment allows students and instructors to interact in multiple dimensions, to analyze the same data with different tools and to achieve multiple objectives in the scope of the same environment.

(ii) **Global collaboration**: AulaNet™ was created in order to give assistance to the learning process. An integrated environment allows students and instructors to interact in multiple dimensions, to analyze the same data with different tools and to attain multiple objectives in the cooperative apprenticeship ambit of its students.

(iii) **Transparent technology**: In order to facilitate its adoption, AulaNet™ is being designed to function in the most transparent way possible for the users. For this purpose it has a Web browser as an interface. Thus, technically, the only software that a user needs is a browser. Secondly, the independent nature of the Web platform means that it is not necessary for the user to change platform. Thirdly, AulaNet™ will allow the user to re-

use material that he is already familiar with. For example, the user could make a course description typing directly onto a form or uploading from an archive of a text editor. Finally, AulaNet™ has an internal structure and mechanisms that allow students and instructors to manage their data and to make it available on a Web server. The users do not need to know anything about programming or coding and transferring Web documents (eg: HTML, CGI, FTP etc.)

(iv) **Flexibility**: In order to promote its adoption and re-creation, AulaNet™ is being designed to have maximum flexibility in terms of pedagogic beliefs. AulaNet™ foresees resources that support both old and new forms of teaching and learning. On the one hand it gives support to the use of slides and convential printed material, and on the other hand it uses mechanisms like News and videoconferences.

(v) **Construction facility and improving knowledge**: To help students see the evolution of the growth of knowledge, AulaNet™ keeps a log of the various possibilities of interaction. AulaNet™ also has the facility for students and instructor to continue discussing the lecture through a News server, after it has been presented by the instructor.

(vi) **Common technology**: The use of available technologies reduces costs and encourages adoption reducing the task of training the users. AulaNet™ has a set of existing tools interfaced by the Web.

(vii) **Evolution of knowledge and ability**: Instead of offering a fixed set of instructional material, AulaNet™ creates an environment in which courses can be in a state of permanent evolution. For example, the students' work from one course will be available as subsidies for students on the next course.

(viii) **Access to course archives**: The content of the courses created with AulaNet™ evolve with time and are archived in a database. All available information can be easily retrieved at any given moment.

4. Emerging Model for Servers of Web-based Courses.

Hundreds of examples of courses developed on the Web can be found in the World Lecture Hall at Texas University [10] and in [11], including courses [7] and [8], developed in the LES at PUC-Rio. The level of use of technological resources adopted by the different courses presented there varies considerably. Nevertheless, based on an analysis of the courses archived there, on the great amount of references available in [12] and on the book edited by Badrul H. Khan [13], it was possible to identify the appearance of a general model for the development and maintenance of Web-based courses. The emerging model is made up of seven stages: (1) Creation of content; (2) Creation of a course on the server; (3) Uploading content to the server; (4) Interaction between administrator and system; (5) Interaction between instructor and system; (6) Interaction between students and course and (7) Interaction between instructor and course.

5. Image and Audio Transmission

The Information Society course [8] was administered at PUC-Rio during the second semester of 1997. On the course two technologies that allow image and audio transmission through the Internet were tested. This experiment was later used in the design of the AulaNet™ environment. Rio Internet TV [14] supported this course through the transmission and recording of lectures.

Rio Internet TV is a nucleus of research at the LES whose objective is to study videoconference as a tool for cooperation in groupwork. The experiment was carried out in stages to observe the performance of various different technologies and configurations.

A student may attend a lecture synchronously or asynchronously. A lecture may be transmitted live or recorded and attended by the student at another time that is convenient for him. Live lectures also offer the option for interaction between instructor and student.

The first technology used for transmission of the lectures was CU-SeeMe, initially developed by Cornell University in the United States. The CU-SeeMe reflector is a server that allow various participants to connect to a videoconference. By connecting through a client—which could be a commercial version like White Pine Software's [15] or an academic version like Cornell University's [16]—it is possible to connect to a CU-SeeMe reflector and to take part in a multimedia conference—video, audio and text. CU-SeeMe technology is suitable for transmissions that need interaction, like for example, lectures with constant interaction between instructor and students, study sessions between students, sessions for clarifying doubts and group exercises, etc.

The other technology tested during the Information Society course was Real technology, which allows audio and image to be broadcast. This technology also has a client/server architecture. The Real server is responsible for the supply of audio and video streams that are compressed by a proprietary algorithm. The client side consumes the streams through a specific software —Real Player—or a browser plug-in, thus permitting the image and audio to be presented on a Web site.

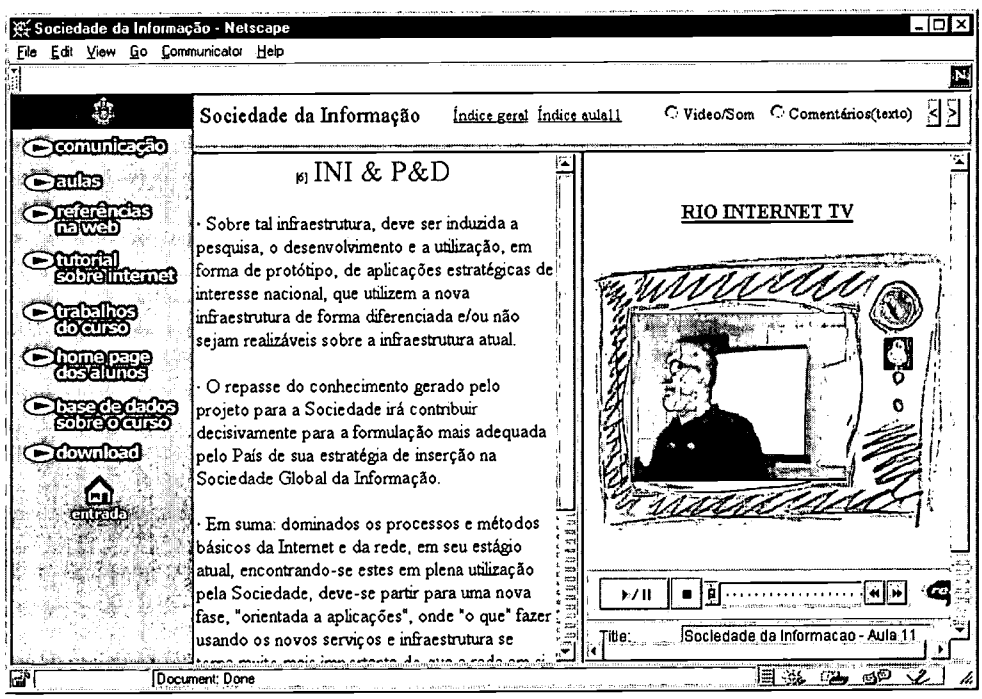
Real technology does not yet offer the possibility of interaction between instructor and student. The advantage of this technology is that it uses the TCP/IP protocol for audio transmission, which guarantees that audio will arrive without any errors. In this way it is possible to ensure a continuity

of the sound, so students are (always) able to understand the information being transmitted. Previously recorded lectures can be transmitted on demand through the network as well as any video that has been edited through some other technology and converted to the Real format.

Live lectures use a combination of the two technologies. Real technology is more suitable for the transmission of broadcast image and audio, while CU-SeeMe is suitable for interaction between instructor and student.

The asynchronous consumption of lectures that needs interaction is done through recording lectures live that are later put on the course site, where one can watch them and read the text of the slides presented, as shown in the figure below.

During the first stage, the Rio Internet TV Reflector was used to transmit the lecture. A special room was created in the Reflector and only the machine installed in the classroom had permission to send audio and video. The other participants could only communicate via chat. This stage was divided into three phases. In the first phase the other rooms in the Reflector remained open to the public and the transmission rate of the lecture was 80kbps. In the second phase the other rooms in the Reflector were closed for sending audio and video, which improved the transmission performance. In the third phase the transmission rate was raised to 300kbps. Within the university's internal network, reception of the lecture was very good, with continuous audio and quite well defined images. Outside the university environment the reception varied a lot depending on the participants' connection. The main problem was discontinuity in the audio as CU-SeeMe does not buffer information.



During the second stage, as well as transmission through the Reflector, the audio of the lecture also began to be transmitted and recorded via Real technology at a rate of 6.5kbps. It was verified that the audio transmitted by Real arrived with greater continuity despite suffering a longer delay than through CU-SeeMe. Real also buffers transmission, resulting in less information loss, which is critical in the case of audio.

In the third stage, we began to transmit and record audio as well as video. In order to do this we used a machine with greater processing capacity. The transmission rate of the audio and video set through Real was 20kbps. People who participated from a long distance reported good audio and video reception with some interruptions in the audio, nevertheless the information was received.

6. Description of AulaNet™

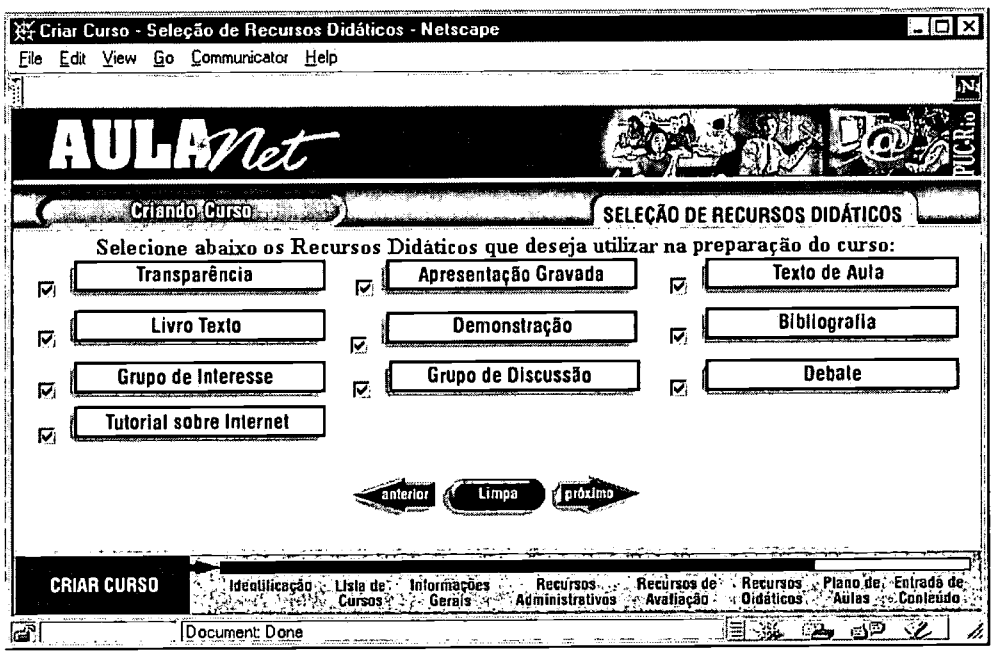
AulaNet™ is a software environment based on the Web developed at the Software Engineering Laboratory—LES—of the Department of Computer Science at PUC-Rio, for creating and attendiing distance courses.

AulaNet™ was conceived from the experience gained in three courses during the second semester of 1997 [7, 8, 9], and is based on the following basic premises:

1. The courses created must posses great capacity of interactiveness, in order to encourage intense participation by the student in the learning process.
2. The author of the course does not need to be a specialist on the Internet.
3. The resources offered by the creation of the courses must correspond to those available in a conventional classroom, plus others normally available in a Web environment.
4. It must be possible to re-use the contents already existing in digital media, through importing archives, for example.

Attending to the above premises led to the formulation of the concept of an **Apprenticeship Development Process**—ADP—discussed above, which demands that the author previously specifies the didactic resources he will use while developing the course, as can be seen in the figure below.

With AulaNet™ it will be quite easy to create distance courses through the Internet, that have a high level of interactiveness and intense student participation, without the author needing to be an expert in Web environments. Furthermore, the course created will use contents that already exist that have been recorded on a digital medium.



6.1 Actors

AulaNet™ considers that the following actors are involved in the authorship/apprenticeship process.

1. The Author: is the creator of the course, who participates from the initial description until the content is entered. He may or may not be the person responsible for applying the course. If he is, then he also performs the function of the instructor, who may or may not have the help of a monitor, who deals with the practical aspects of the course and helps in assessing students.
2. The Student: is the final user of the course, representing the target-public, for whom the final product obtained by the use of AulaNet™ is intended.
3. The Administrator: facilitates integration between instructor/course/student, and deals with matters of a predominantly operational nature, like enrolling students and making the course agenda and course news available etc.

6.2 Resources

With reference to the creation of the course, AulaNet™ offers the author the possibility of selecting various resources that will be used by him or by the other actors in the final assembly of the course and that will be converted into services, afterwards. The resources in AulaNet™ come under four group headings:

1. Teaching Resources: correspond to the pedagogic tools that will be used during the application of the course and must be previously selected by the author.

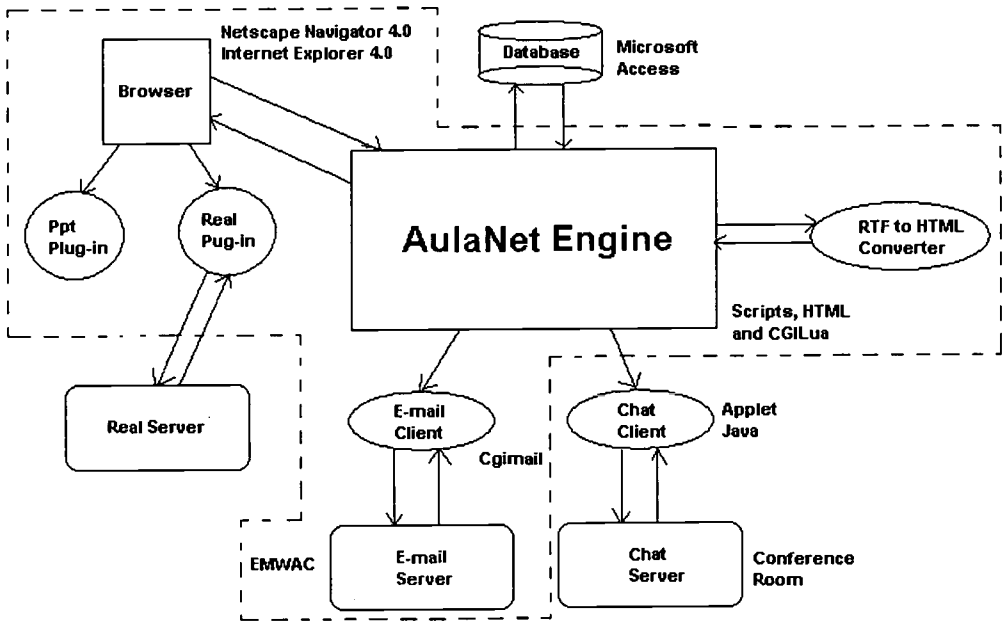
2. Assessment Resources: correspond to the formats that will be used by the instructor to make an assessment of how well the students benefitted from the course.
3. Administrative Resources: are necessary for establishing operational communication between students and the institute responsible for the course.
4. Fixed Resources: are resources used in any type of course, that support the basic operation of AulaNet™.

The resources selected by the author are converted into services supported by AulaNet™.

In order to provide all the necessary services, AulaNet™ has a set of software tools some of which, like freeware, are available on the Internet, others have been developed by the team at the LES.

7. Architecture of the Environment

The architecture of AulaNet™ is based on the Web, where the environment interface is being developed, and CGI (Common Gateway Interface) [17], that implements all the features of the server. The figure below is a view of this architecture. All the software contained in the dotted area were either developed at LES or are software (Netscape Navigator [18], Internet Explorer and PowerPoint plug-in [19], RTFtoHTML [20], CGIMail [21], EMWAC listserver [22] and Real plug-in [23]) available on the Internet. The Real Server [22] and the Webchat Conference Room [24] are commercial software.



All the objects manipulated by the environment, like for example courses, students, institutes and departments, are stored in a relational database, that is responsible for the persistence of these objects. The CGI interface between the database and the application is done by a layer of Lua objects. This layer is responsible for the manipulation of all information about the environment and for the integration of AulaNet™ with external helpers, used to perform some of its services like discussion groups (listserv) and transference of archives via the Web (file upload).

AulaNet™ authorship and apprenticeship modules were implemented in CGILua [25] and are clients of the Lua objects server. Their respective interfaces are responsible for validating data on the client's side using JavaScript code [26]. With the architecture proposed for the AulaNet™ environment we managed to achieve a high rate of reuse through use of components. The Lua objects server layer is also responsible for the definition of the interface of the objects of AulaNet™ servers. It works like a facade, as defined in the design pattern Facade [27].

8. Preliminary Comparison with other Systems

All the environments for Web-based education and training, that follow the emerging model described in section 3 are very recent (they were developed at the end of 1996 or during 1997). We have examined in great detail the following seven environments in order to carry out a preliminary comparison:

- Classnet, developed by Iowa State University Computation Center [28]

• Web-Course-in-a-Box, developed at the Virginia Commonwealth University [29]

• Virtual-U, produced by Simon Fraser University [30]

• WebCT, developed at the University of British Columbia [31]

• Webstudy, a commercial environment for the university market [32]

• Serf, developed at the University of Delaware [33]

• Learning Space (commercial – IBM)

The comparison with these systems must be preliminary because all systems are still at a very early stage of their life cycle. Up till now, the system that has been most widely tested is the WebCT environment from the University of British Columbia that has the cooperation of various other universities for testing the system.

From the point of view of features, the seven systems compared with AulaNet™ are more concerned with assessing the students than creating resources for authorship and interactivity. Broadly speaking, AulaNet™ uses more tools and resources on the Web than the other systems.

There are two reasons justifying why the current version of AulaNet™ does not put so much emphasis on assessment: the first main concern with AulaNet™ was to make it acceptable for instructors and students, later on a complete assessment system, already in development in the LES, will be integrated into the environment.

Creating and attending courses through AulaNet™ seems more simple than through the other systems, but this is a very preliminary comparison that must be confirmed as the communities of users of the various environments grow.

9. Conclusion and Future Results

The future of the AulaNet™ environment, as well as the other systems mentioned in the previous section will depend mainly on their acceptance by a wide community of users. It is very probable that interaction between the developing team and users will lead to sensitive modifications, for example, in the system interface.

Judging from experiments conducted at the same time as AulaNet™ was being developed, the authors believe that, the use of the Web as a complementary or exclusive form (eg. "just-in-time" training) of offering courses substantially enriches the current methods of applying technology to education.

Spider, a visual language and environment [34], was also developed in the LES, the laboratory where AulaNet™ was developed. In Spider, the logic as well as the interface of a system can be expressed graphically as long as an architecture of classes is developed for a specific application area. There is already an architecture for Web-based applications available that will be complemented by an architecture based on the AulaNet™ application classes. We anticipate that in the near future the evolution of AulaNet™ will take place through this strategy.

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