Using the WWW System Hyperwave as the Basis of a General Networked Teaching and Learning Environment

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In this paper we show that the WWW Technology Hyperwave is a good basis for the development of a GEneral Networked Teaching and Learning Environment (GENTLE). After a short introductory section we discuss some features of Hyperwave that relate to educational matters. We then present a summary of GENTLE as it is currently being implemented phase by phase.

Keywords: Web-based learning, training, teaching, WWW for education, Hyperwave, CAI

1. Introduction

The history of efforts to use computers for educational purposes is over 35 years old and is (overall) a history of failures. An analysis why this is so is contained in chapter 1 of [29] and will not be repeated here.

Let it suffice to say that all attempts, so far, have had serious deficiencies one way or another. Some of them due to technical reasons, some due to the lack of pedagogical theories, most of them through a combination of both and the fact that no system has provided enough flexibility. None has provided a rich enough variety of learning and teaching models allowing it to be tailored towards specific subject areas and particularly towards individual student knowledge acquisition techniques.

In this paper we first review those features of the new WWW technology Hyperwave in section 2 that relate to educational matters. Then we present the main elements of GENTLE by formulating ten important guidelines.

GENTLE is not trying to follow a particular cognitive paradigm. Rather, it tries to provide facilities that allow the incorporation of very diverse models of knowledge transfer. Its success will be measured by how flexible educators and students will find the system for the adoption to their needs.

Section 3 of this paper contains the "Ten guidelines for GENTLE" that we consider necessary ingredients of any integrated network-based learning environment. The aim of GENTLE is to create an environment satisfying the ten guidelines; it uses the currently most advanced WWW server system Hyperwave (see e.g. http://www.hyperwave.com and references mentioned later). The guidelines have been derived from much research and concrete experiments starting with COSTOC (e.g. [21], [9]), to HM-Card (e.g. [28], [29]), from work in digital libraries (e.g. [27], [22], [19]) to the development of the advanced WWW-server system Hyperwave (formerly Hyper-G) e.g. [13], [7], [2], [24]), and taking into account recent related work such as [30], [1], etc.

In a final section we give a short summary followed by a list of references.

2. What is needed from WWW servers for educational applications

Assuming that we have a large set of educational modules and want to use links as known from WWW as part of our navigational tools, we immediately note a basic problem with the ordinary WWW link concept. In this concept the source anchors of links are embedded in a static way in the documents. Thus, if we have specific document formats that are interpreted using special plug-ins or helper applications, then the anchors inserted destroy those formats, hence requiring a re-write of all viewers involved. A way to solve the problem is to treat anchors (source and destination) not as parts of the document but as separate objects in a separate database. Doing so immediately also offers another big advantage: by assigning attributes to the link objects many important other uses become possible. E.g., access rights to links can be made different from the access rights of the underlying document. Thus, the document may be visible in the same way for a certain group of persons, but some links may only be visible to designated persons or groups of persons: this means that links for "private" or "group-use" are possible. This is the first important step towards being able to customise educational material for special purposes without object replication. Since links and underlying documents may have different access rights it is possible to e.g. "freeze" documents, yet allow changes or additions of links, of paramount importance when students or teachers want to add remarks or links to other material. Note that links in ordinary WWW are unidirectional. If three documents X,Y,Z have a link to a document A, and A is removed, three "broken" links remain in X,Y,Z and can only be corrected by the owners of the documents X,Y,Z. Storing links in a separate database with separate attributes allows us to follow the links from A back to X,Y,Z (i.e. introducing bi-directionality) and to deactivate the links in X,Y,Z without having access rights to X,Y,Z: thus, using the technique described automatic link maintenance becomes possible.

We thus see as basic requirement that links are available in all media documents, that link maintenance is easy and that educational material can be customized. This automatically leads to the need for non-embedded, bi-directional, typed links.

Note that already [35] has pointed out the analogy between goto's and links. Indeed, goto's in programming languages, explicit pointers in data structures and links are very similar concepts. In programming and data structures we have learnt that explicit goto's and pointers should be replaced by structure wherever possible. The same clearly applies to WWW: explicit links should be replaced by introducing structural constructs. The most obvious way to define structure is to use hierarchies similar to the directories we know from computers. A closer look reveals that a somewhat more general structure that allows multiple classification of objects and groups of objects is more desirable and – together with customised links – eases the customisation of educational and supporting material. Note that grouping documents in "collections" and collections again into collections, etc., not only will help to reduce explicit links, it will also help searching (by allowing us to restrict attention to a specifically defined set of collections) and – as by-product – allows a systematic distribution of documents to physically different servers, easing the problem of handling distributed databases, e.g., educational material produced and residing in different physical locations.

We have seen that is it necessary to assign attributes to links to make them more flexible. In analogy it should be clear that such attributes are also valuable for documents or collections of documents e.g. for searching purposes in a "background library".

The above considerations have shown that a number of obvious wishes (handling a variety of media types, customisation and search facilities, automatic link maintenance and distributed databases) naturally lead to certain extensions of WWW. As we will see below, WWW servers used for educational applications have to meet still further requirements.

Ordinary WWW servers are easy to install and clients are available on all major platforms. Much software is free and sources are sometimes available. The node-link technique for navigating and finding information is quite appealing for small to medium amounts of data, and the mix of media makes the use of WWW aesthetically pleasing. All this has contributed to the proliferation of WWW. The success of WWW, the number of WWW proponents and freaks and its publicity even in non-scientific publications may create the impression that WWW, as it now exists, is the solution for most information needs and defines the dominating technology for the foreseeable future, even for educational applications.

However, the reality is different. Whilst WWW is undoubtedly a big step forward, compared to pre-WWW times, experience shows that much functionality required for sizeable applications is missing from ordinary WWW, as already indicated above. In this sense, ordinary WWW should be considered as the first generation system: while e.g., pure node-link navigation is satisfactory in small systems, it tends to lead to confusion and disorientation, if not chaos, when applied to large amounts of data. For substantial applications, some additional structuring and searching facilities are clearly required. That links may actually be more harmful than useful has already been pointed out in [35] and elaborated in [26]. Similarly, the necessity to keep links separate from rather than embedded in documents, which is the case in most current WWW systems as explained in the previous section, has already been demonstrated in the pioneering work on Intermedia at Brown University [10]. HyperWave [24] and Microcosm[11] are the only two major systems that support this important feature at the moment.

Information in a hypermedia system is usually stored in "chunks". In ordinary WWW, a chunk consists of a single document. Documents may consist of a combination of arbitrary multimedia elements. To give a simple example, a document may consist of textual information and may include pictures and the (source) anchors of links.

In Hyperwave the setting is considerably more general: chunks, called "clusters" in Hyperwave terminology consist of a number of documents. The support for multiple pieces of information within a cluster allows Hyperwave to elegantly handle the case where a document comes in multiple versions: e.g., a more technical (or advanced) one and one more suitable for the novice reader or different versions for different bandwidth or for different drivers, like offering the choice of picture, video or 3D scene depending on the user's environment. What is most important, clusters allow the automatic support of different learning styles like e.g. "verbal", "symbolic" or "visual".

In Hyperwave not only can links have a type, links are by no means the only way to access information. Clusters of documents can be grouped into collections, and collections again into collections in a pseudo-hierarchical fashion. We use the term "pseudo-hierarchical" since, technically speaking, the collection structure is not a tree, but a DAG. This means that one collection can have more than one parent: an impressionist picture X may belong to the collection "Impressionist Art", as well as to the collection "Pictures by Manet", as well as to the collection "Museum of Modern Art". The collection "hierarchy" is a powerful way of introducing structure into the database. Indeed many links can be avoided this way [26], making the system much more transparent for the user and allowing a more modular approach to systems creation and maintenance. Collections, clusters and documents have titles and attributes. These may be used in Boolean queries to find documents of current interest. Hyperwave also provides sophisticated full-text search facilities. What is most important, the scope of any of such searches can be defined as the union of arbitrary collections, even if the collections reside on different servers. The concept of collections has another very significant advantage: it allows insertion and deletion of documents into a Hyperwave database without any link adjustment, a luxury unknown in ordinary WWW systems. Finally, and for educational applications particularly important, having learning modules packaged as collections eases modularization and re-use of material.

Note that some WWW servers also permit full-text searches. However, no full-text search engine is part of "standard" WWW. Thus, the functionality of full text search is bolted "on top" of most WWW servers: adding functionality on top of WWW leads to the fragmentation of WWW, since different sites will implement missing functionality in different ways. Thus, to stick to the example of the full text search engine, the fuzzy search employed by organisation X may yield entirely different results from the fuzzy search employed by organisation Y, much to the bewilderment of users. Actually, the situation concerning searches on most WWW servers is even more serious: since documents in such WWW servers do not have attributes, no search is possible on attributes; even if such a search or a full text search is artificially implemented, it is not possible to allow users to define the scope for the search, due to the lack of structure in most WWW databases. Hence full-text searches on most WWW servers always work in a fixed, designated part of the database residing on one particular server.

Hyperwave provides various types of access rights and the definition of arbitrarily overlapping user groups. Hyperwave is also a genuine distributed database: servers (independent of geographical location) can be grouped into "tribes" that act as one logical system. Thus, users can define the scope of searches by defining arbitrary sets of collections on arbitrary servers. Note further that proper authorisation schemes allow different groups to work with the same server without fear of interferring with each other's data.

In ordinary WWW servers documents are stored as such, without any "meta-information", i.e. without any information about the documents. In contrast, in Hyperwave every document has some standard attributes and arbitrary further ones as defined by the user. Standard attributes include the author, creation date, date when the data is to be made public, expiration date, keywords, etc.

Note that such attributes are invaluable for searching and for administration. Typically, if a document concerns an event on a particular date, clearly the document should be removed (and links pointing to it deactivated) after this date. In ordinary WWW systems this has to be done manually. It requires much effort, tends to lead to many documents whose removal has been forgotten and hence are obsolete, and adds to links whose activation results in a message "object not found" or such, since when the document was removed the deactivation of some link in some document was forgotten. In Hyperwave a document as mentioned would be entered with an appropriate expiration date. Removal of the document and the deactivation of links pointing to it can be handled by Hyperwave without manual intervention.

Ordinary WWW systems have traditionally been seen mainly as (simple) information systems. Most applications currently visible support this view: very often WWW servers offer some pleasantly designed general information on the server-institution, but only rarely does the information go much deeper. If it does, usually a "hybrid" system is used, WWW with some add-ons or a database in the background using the scripting interface of WWW.

It is our belief that hypermedia systems acting as simple information systems for educational material in the sense of electronic books, where someone inputs information to be read by other users, do not offer much potential: they will disappear into obscurity sooner rather than later. To ensure the success of a WWW system for educational purposes, it must also allow users to act as authors, allow them to change the database, create new entries for themselves or other users, create a personal view of the database as they need it, and, above all, allow the system to be also used for communication and co-operation.

Ordinary WWW systems almost entirely lack support for such features. Emerging more advanced hypermedia systems are bound to incorporate more and more features of the kind mentioned; Hyperwave provides a start.

Hyperwave supports annotations (with user-definable access rights): Hyperwave annotations become part of the database, i.e., are also available when working with other clients, or from another user account or machine. Annotations can themselves be annotated; the network of annotations can be graphically displayed using local map functions. Thus, the annotation mechanism can be used as the basis of (asynchronous) computer-conferencing, and has been successfully employed in this fashion. It can also be seen as allowing users to write private remarks in the "margin" of the material examined for later review purposes.

We believe that many of the features discussed in the area of computer-supported cooperative work (for a compact survey see [8]) will eventually be incorporated into advanced hypermedia systems.

As has become clear from the above discussion, ordinary WWW servers do not have enough functionality to provide a solid and unified basis for substantial multi-user multimedia repositories with a strong communicational component.

Hyperwave is the first attempt to offer much more basic functionality, yet to continue to work as WWW system: every WWW client can be used to access every Hyperwave server.

It is our content that ordinary WWW and HTML should be seen as "thin interface layers" (and this is how Hyperwave treats them), but more powerful tools must be used as further underpinning (and this is what Hyperwave does). For detailed but somewhat dated information see the "HyperWave" book [24]. An electronic version of this book is available under http://www.iicm.edu/hgbook. Up-do-date information on Hyperwave can be found in the manuals on http://www.hyperwave.com.

It should also be clear, however, that Hyperwave is just the first step in a necessary direction for large repositories of educational or other material and that further steps will be unavoidable. Only the actual use of very large WWW multimedia databases will show what new features or concepts will be needed for educational applications.. However, sizeable databases like the AEIOU project http://www.aeiou.at (an 8 Gbyte presentation of Austria!) or the LIBERATION project http://www.iicm.edu/liberation do demonstrate that techniques such as the ones explained and realised in Hyperwave work well and replace much manual work while insuring consistency of the database.

After having discussed Hyperwave in some detail we now present the key features needed from a GEneral Networked Teaching and Learning Environment.

3. The ten guidelines for GENTLE

In this section we present ten general theses (guidelines) that must be kept in mind when designing or evaluating an integrated teaching and learning environment. Some of them have already been analysed in more detail in LATE (see [25]) with potential good background reading. Note that the ten theses presented are also seen as the basic guidelines for the project GENTLE mentioned earlier.

Thesis 1: No matter what technology is used, insights obtained from traditional courseware design both from a pedagogical and content/form point of view must not be ignored.

It is amazing to see that in current multimedia efforts based on HTML pages, HyperCard or Macromedia derivatives and many similar lessons learnt (see e.g. [17], [32]) on courseware design are completely neglected. Too many persons seem to believe that linking a few HTML pages together produces viable material for teaching and/or learning purposes. Whenever a substantial piece of courseware is designed it is e.g. essential that aims and prerequisites are clearly stated, that the material is well motivated, that features technically available like fonts, colour, graphics, animations, etc. are not used as gadgetry but only when helping to understand the issues to be communicated; that student interaction beyond ‚electronic page turning" is essential and can often be achieved using checkpoints with feedback, built-in simulation, guided tours of material presented in one window, a second window used for guidance; that the level of the material is sufficiently concrete (e.g. through the use of examples); that the tone is personal yet not condescending, etc., etc. We refer to the literature mentioned, including chapter 6 of [29] for more details. However, we want to point out that most technologies allowing the creation of courseware permit the creation of both well-done and unsuitable material. They usually do not provide ‚built-in guidance" to avoid at least some of the most glaring pitfalls. We consider this an important area of work, yet an area not directly addressed in GENTLE, that (see below) takes an open view as far as "authoring tools" are concerned. However, GENTLE includes an "Authoring Whizzard" and "Editing Whizzard" as parts of the overall project.

Thesis 2: The production of high-quality courseware has to be made as easy as possible.

In a system like GENTLE this means basically five things. First, the system has to be open to let authors choose their preferred tools; second, techniques such as ‚authoring on the fly" (a term first coined in [23] and successfully pursued by the group of Thomas Ottmann at Freiburg (see [2] for a concrete implementation and [20], [18] for background ideas) has to be supported as much as possible; third, software must include simulation and interactive techniques; fourth, statistical information and feed-back from students has to be provided by the system for the improvement of materials; and fifth, courseware has to be designed in a modular way so that it is easy to update and reuse.

It is the last issue that is maybe the most important, yet often overlooked aspect. It is one of the many reasons why ordinary WWW where all the structure is built into the links cannot be seen as serious candidate for sophisticated

GENTLE-like systems. A system such as Hyperwave is needed to be able to structure the material into modules (called "collections" in Hyperwave) that can be reused and updated without the need to change any links to and from them. The HM-Data model [28] is another step in the same direction and so is HOME (see [6]).

Thesis 3: We need guidance but not dictatorship.

Early CAI/CBT systems were often suffering form the "tunnel syndrome". When working through material you felt "locked in", scarcely able to leave the predefined route, let alone look up electronic background material, have an electronic chat with others, etc.

The advent of WWW turned this all 180 degrees around. Suddenly, there was unlimited freedom, a spaghetti-bowl of links to be followed, the "tunnel syndrome" suddenly replaced by "lost in hyperspace". Neither for teaching nor for self-studies (and we return to those two separate aspects of the use of networked multimedia material in Thesis 10) do we want either of the above phenomena. For GENTLE this means three things: first, a certain amount of guidance through the material to be learnt is provided; second, at each moment in time, the control on where to continue, rests with the student, not with the system; third, throughout the knowledge acquisition process the "guided path" can be left in favour of many other activities (see through Thesis 2 to 7), but in particular it can be left to consult an electronic library residing in the background. Such electronic background libraries may range from a small selection of dictionaries, books, supporting multimedia material and software to very large electronic archives covering all kinds of knowledge. To be able to work efficiently, this knowledge must again be structured, and "search scopes" depending on personal profiles must be definable, else the typical information overkill of your experience with search engines on the Web is unavoidable.

Thesis 4: Facilities for annotations are essential.

As you are working through some material, be it courseware in the classical sense, an electronic book, a library of pictures or whatever, you must have the possibility to add personal notes. Such personal notes can be text, pictures, arbitrary documents or even links to other material: how often has it happened to you that you found a piece of information x that you wanted to link to information y so that on revisiting x you would find your note and the link to y but you could not do so. After all, in ordinary WWW systems you cannot add links to documents that don't belong to you. In GENTLE you can. And your notes (or links) are visible only to you, a group you define, or to the general public, just as you decide.

Thus, annotations not only permit you to add notes as if "writing into the margins of a book", they allow you some customisation (personalisation), a crucial issue that is the central point of Thesis 10.

Thesis 5: Facilities for asynchronous computer conferencing are imperative.

As important as it is to be able to take notes and attach them wherever suitable, it is still more important in many situations that others can read your notes, can comment them (i.e. attach their notes to yours), etc. Thus a general annotation concept as described in Thesis 4 actually leads automatically to the important tool of asynchronous computer conferences (ACCs).

ACCs in their most simple version are like newsgroups or bulletin boards. However, often a better structure (to be able to follow the thread of a discussion) is preferable. Observe further that one and the same document should be able to show a completely different set of annotations, i.e. different ACCs, depending on the group of users accessing the document. GENTLE type systems will usually require some kind of identification (see [8]) to be able to distinguish various ACCs. It is also desirable to combine ACCs with mail systems. A minimal solution is to inform members of an ACC by e-mail that new contributions have been added to the ACC. Observe that ACCs are a natural extension of (semi-public) annotations and can be a major factor in any teaching and learning environment. It is often desirable to have "moderated" ACCs to avoid the possibilities of "disintegration" of ACCs that is sometimes observable. In passing we observe that ACCs structured as a three-dimensional world offer further new and attractive alternatives. Note that by allowing "group annotation" Hyperwave has already built-in basic ACC concepts.

Thesis 6: Question/Answer dialogues should be possible where users need them.

In traditional CAI/CBT systems authors of courseware usually attempted to predict locations in the material that would require further elaboration (and would offer additional information if you decided you needed help); or they tried to determine if you needed help by "asking questions" and reacting to the answers received.

In GENTLE, this "static model" of question/-answer dialogues is replaced by a much more dynamic approach. First, the system may ask you questions in the traditional sense, mainly for self-test and selection of material purposes as explained under Theses 9 and 10; second, and much more important, you as user can ask a question at any point as a kind of annotation: it may be a question to fellow students or to a tutor or teacher; and you may get immediate feedback if one of the persons addressed is currently on-line (e.g. if you ask a question during the official "electronic office hours" of a tutor). Observe that the "technology" of asking and answering questions may vary from text-only, to audio, video, or even 3 D, and may be affected by bandwidth, available hardware, etc. Thus, a general system should allow a "graceful" degradation where necessary.

Thesis 7: An integrated teaching and learning environment needs synchronous communication facilities.

The possibilities alluded to in Theses 5 and 6 might leave the impression that no further communicative features are required. However, numerous experiments have shown that additional functions are required.

First, there is the need for "chatting", where short individual contributions are not treated as separate documents but rather as one dynamically growing (and potentially non-persistent) document. Chats often tend to degenerate, particularly if there are more than just a few participants. For this reason it is important to be able to initiate chats only with persons interested in similar topics. Typically, if you work through some chemistry material you may want to chat with fellow chemists, but not with persons currently working on Chinese literature. To be able to narrow down the set of persons potentially interested in a chat it is thus necessary to have the material in a GENTLE system systematically structured, as is e.g. possible using Hyperwave.

Second, chats alone are not enough. Of paramount importance is the availability of an electronic workspace (often in the form of a so-called whiteboard but in future also more and more in the form of 3D worlds populated by "avatars" presenting other persons present) that can be shared by a number of users. Typical applications include a "follow me" mode where one person leads others through some WWW pages, software package, etc., with "conversations" between the participating persons going on at the same time. Such a workspace can also be used for co-operative work (on a piece of text, at graphic design in a 3D scene, or whatever) and is particularly useful for explanatory purposes: a question concerning a particular document can be answered and discussed in detail while the document is visible to everybody involved.

Another important way of synchronous collaboration is found in so-called "decision room scenarios". Typically, a topic is discussed in a strictly anonymous fashion (to overcome otherwise inherent fears of voicing unpopular opinions). Sometimes this is just done for "brainstorming" purposes, sometimes the result may be an anonymous vote on how to proceed in a certain matter.

Thesis 8: Question/Answer dialogues should become part of the multimedia database.

As has been explained in theses 6 and 7 there are various ways how questions can be asked in a GENTLE system, and how and by whom they can be answered. While some of the dialogues (e.g. in the chat mode) might well be considered volatile (transitory), other question/answer dialogues should be archived for future use.

Typically, if a student asks a specific question and a tutor answers it, this question/answer pair should be recorded so that when other students ask a similar question the system automatically can present the answer that might well have been given months ago! Clearly, if such a mechanism can be implemented, whatever material is at issue it will eventually be enriched by "all possible" questions and answers to them. The difficulty clearly is how the system can recognise that question x is similar to question y. This is (almost) impossible even if x and y are text-only questions, and becomes still more intractable when x and y are formulated using spoken language. However, it has been argued in [25] that by using the user's rather than the system's intelligence many of the problems can indeed be solved. Observe further that a piece of explanation soliciting many questions should probably be replaced by a better explanation, anyway!

Thesis 9: Testing and checkpoints are important.

It is, of course, conceivable that a system like MANKIND is enriched by a database of questions and answers and thus can also be used for examination purposes. To discuss the problems involved in this (e.g. from security to how the system evaluates whether a given answer is correct for questions requiring more than the selection of a choice or the calculation of a set of numbers) goes beyond the scope of this paper.

Note, however, that testing and checkpoints can and should be used for a variety of other purposes.

First, a pre-test can lead to selecting the proper set of "teaching modules" in the right order (we return to this in Thesis 10). Second, material for self-testing is important for both material repetition (and hence retention) but also as indication to the users how much and how deeply they have understood what has been discussed. Third, exercises – even very complex ones – are of high pedagogical value, even if (as would usually be the case) the system itself cannot judge the quality of results: the system may present a number of good approaches, plus a number of bad ones – and leave further judgement to the user; the results may be checked (asynchronously or synchronously) by a tutor, or by fellow students, and students of tutors may even decide to incorporate good approaches permanently into the system. This leads to the fourth aspect, the aspect of voting and of "anonymous discussions" much as mentioned in decision room scenarios at the end of Thesis 7.

Thesis 10: GENTLE cannot live without customisation.

The GENTLE ideas described so far present a fairly general and flexible integrated networked teaching and learning environment:

On the basis of existing modules new "courseware" is built rapidly and with high quality; you can peruse it at your own speed, and under your complete control; you can browse in background libraries, add notes for yourself and others, participate in discussions and votes, ask questions to fellow learners or tutors; and, in doing so, you increase the knowledge in the database and you provide important feedback; conversely, the system asks you for your participation, for completing exercises and presents the tests which help you retain the material and show you your level of proficiency.

However, the most important aspect of GENTLE is still to be discussed: the aspect of customisation that makes the learning modules fit your needs: your needs will be different from the needs of others for at least three reasons.

First, different persons have different learning styles. According to the often quoted theory by Meeker persons belong to one of the three types: verbal, symbolic and visual. In a perfect environment each "module of knowledge" should exist in a verbal, symbolic and visual form. Depending on the individual learning and retention style (which can be determined by appropriate pre-tests) you should always receive modules that correspond to your learning style, a style you may wish to "override" once in a while. Even within styles there are differences.; you may prefer the text to be visually displayed or spoken; often a few written words but a fuller audio explanation (if selected) may be the most desirable mode – particularly if you use the material not for self-study but e.g. for teaching others (in a classroom situation with a videobeam).

Second, different persons have different backgrounds. Learning material has to be broken up into very small modules. Intensive pre-tests should be used to determine which modules are useful in which order. This combination of modules depending on the person's background is only possible if links between the modules are not part of the modules, but are, e.g. available as structural information or such.

Third, the environment (equipment, bandwidth, location of equipment, ...) and how it is going to be used (by a teacher, a student, a group of students, ...) will also influence the kind and format of the material applicable.

Putting this together, learning environments without customisation facilities can never provide satisfactory solutions. In a WWW environment this means that ordinary servers won't suffice unless an exorbitant amount of scripting is done. Hence the more powerful WWW solution, Hyperwave, has been chosen as the basis for GENTLE.

4. Summary

We have discussed some features of the new WWW technology Hyperwave, and why it is essential to use it (or a similarly advanced system) for educational applications. We have shown that an ambitious distributed educational project can be (and actually is currently) built based on Hyperwave.

Hyperwave originated as a university prototype named Hyper-G, but is now supported worldwide by a company Hyperwave Information Management Inc. (see http://www.hyperwave.com).

The GENTLE project is managed by AWAC (the Austrian Web Application Center), a division of ARCS (the Austrian Research Centers) under my supervision. Persons and organisations interested in cooperation are cordially invited to contact me at hmaurer@iicm.edu.

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