THE ESSENTIAL SPECIFICATION FEATURES FOR COMPUTERISED DELIVERY OF TAUGHT MATERIAL

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Abstract *¾ This paper describes the design of a platform-independent delivery mechanism for on-line lectures that may be used live in the lecture theatre and during private study (at home or in the workplace). The essence of the system is twofold. First there is a simple and complete specification for ordering lecture-based multimedia content that aligns itself with the lecturer's ability to create well-organized lecture material. Second, it has a delivery vehicle that interprets that specification so that the lecturer's user-interface design skills are not required. The physical realization and the temporal behaviour of the necessary functions are detailed. The rationale for openness enabling the lectures to be integrated with other material for inclusive single-step searching is discussed. Such a facility must have a manual interface and enable a learning support tool to find material automatically for remedial teaching.*

Index Terms ¾ On-line lectures, multimedia, distance learning, XML.

INTRODUCTION

Information and Communication Technology (ICT) offers the teacher an enhanced means of conveying taught material in both the school classroom and the university lecture theatre. But feature-rich specification languages, fully supported by a graphical editor, have the adverse effect that an excessive amount of time is needed to create the material; and teachers do not have the time to engage in such activity. Furthermore such complex design systems encourage an unnecessary effort to make the material interactive, almost guaranteeing a navigation muddle that inhibits the fluid live performance. Generally speaking, teachers do not have the design skills to ensure that the interaction is simple and that the interface facilitates intuitive performance.

However, teachers ought to have the skills that enable them to collect, organise and structure taught material to a level appropriate for the students, and then convey that material in a lucid way at a speed appropriate for those students. Normally this teaching activity occupies only a small part of the student learning process. But it prepares the student for a period of private study in which the understanding is achieved in a more efficient manner than would be the case if they simply read the book; lectures oil the learning process that follows on from the lectures. And indeed the lecture helps the student understand the text book while the book, in turn, gives depth and breadth.

Adopting ICT in place of the conventional talk-and-chalk lecture must not impede a smooth and orderly presentation; and where it is appropriate, it should enhance the exposition with meaningful animation and exemplary video fragments all seamlessly combined together. Indeed today's television weather forecasters show just how lecturers ought to use ICT; in practice most lecturers fall short of this ideal mainly because of pointless animation, delays in accessing the next fragment, and difficulty in integrating exemplary material.

Furthermore if ICT is adopted in this way for the lecture-theatre, and the sequence can be imposed with a correctly synchronised spoken narrative, the live experience can (almost) be replicated for those who need to have the lecture repeated, in part or in whole, during private study. And, of course, it can be made available for those studying at a distance. The result is an on-line lecture.

But it is not sufficient to provide linear access to these on-line lectures. Students appreciate being able to adopt and adapt the material to their preferred learning style. It is unlikely that teaching staff would create the same material many times in order to meet those different learning styles. So the material needs to be searchable along with other supporting documents, on-line note-books, and so on in order to find information in a non-linear way without having visually to browse. In particular there should be a means by which, for example, examination questions can be applied to the search mechanism so as to find the slides that cover the material needed to answer the question [4]. Those of an holistic style of learning need to have an overview of the complete module and this should be generated from the lectures themselves rather than be written specially by the lecturer. These requirements mean that the format of the files used must be in the public domain so that they may be appropriately dissected.

REVIEW

The foregoing has argued that lecturers have neither the time nor the expertise to use complex design tools to create good multimedia material suitable for use both in the lecture theatre and by students learning at a distance. In principle, a design aid should be based on the familiar process of creating slides, adding animation and a synchronised narrative so as to exploit to good effect Information and Communication Technology. Along with worked examples created in the same way, the remaining facilities, such as

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search support, should be built automatically without the need for (much) further human intervention.

With an HTML-like syntax, the Synchronized Multimedia Integration Language (SMIL) provides a way of specifying the integration of multimedia material for delivery as a single presentation [10]. It is a complex language, with an excessive requirement for detail, enabling it to provide a high degree of flexibility. Using SMIL would encourage the lecturer to spend an inordinate amount of time on specifying such things as fades and timing; the skill required would not be in learning the syntax but in understanding which technique is appropriate for each situation. This is not the level at which the lecturer should be concerned with the presentation. Indeed, the lecturer would need a tool to help with generating, for example, twenty hours of lecture material. SMIL appears to support a single presentation and so could not be used live in the lecture-theatre. Furthermore it is not clear that the various delivery tools support navigation at a semantic level. For example, the student may want to have a sentence repeated; having to use the controls common in conventional tape-recorders to find the sentence start would interfere with the learning of what is possibly a difficult concept. Furthermore, search tools would not be able to reach a specific sentence and play the presentation at that point.

Another complex multimedia document definition system is described by Soares *et al* [11]. While powerful conceptual models provide expressiveness they also demand complex authoring tools, a situation that is not appropriate for lecturers teaching, for example, history who should not need to develop the necessary authoring skills. Such skills are those required for constructing an abstract structural view using a relation composition tool and for defining the temporal relationship between multimedia fragments using a timeline-based tool. Again, the resultant document does not appear appropriate for both private study and lecture theatre use. The system needs to be able to differentiate between those audio clips containing the spoken narrative that will not be played in the lecture theatre and those clips containing music or the speech of a great orator that would be played in the lecture theatre.

In contrast, ‘Authoring on the Fly’ is a system which supports the organisation of a collection of slides, images, animation programs, audio and video clips, into a sequence for presentation [8]. During the presentation, the lecturer’s (and the students’) voices(s) are captured, together with a graphics stream and the sequence of collected items. In so doing, the temporal sequence is automatically recorded and, of course, integrated. Müller and Ottmann[8] do not explain how easy it is to use the system during a live lecture. It is likely that the manipulation needed, for example to start an animation program, will create long interfering pauses that will be faithfully recorded. They will need to be edited out in the post-processing phase along with the mutterings that often accompany such situations. Excessive ‘ums’ and ‘ers’, the re-recording of difficult explanations that were poorly conveyed, and the insertion of key points that were left out, all have to be included in the post-processing phase. The skill and effort required to adapt the multimedia document into a semi-professional result, demands that a small team helps the lecturer. But the document does inherently provide non-linear access points for use during private study, though it is not clear the level of granularity at which access is possible. Nor is it clear just how easy it is to navigate between one access point and the next. This aspect is given much consideration by Pimentel *et al* in their description of a similar system now called eClass [9].

Müller and Ottmann[8] comment on the need to convert Powerpoint presentations into Postscript documents before importing them into their system; indeed this has to be performed interactively each time the presentation is updated and cannot be performed automatically. The format of the Powerpoint file is not in the public domain, so such presentations cannot be included in an automatically generated multi-source search system without requiring the lecturer to repeat the material in a more open format. For Müller and Ottmann[8], the presentation effects available in Powerpoint cannot be transferred into their system. Thus, Powerpoint is not a suitable delivery vehicle for on-line lectures.

ON-LINE LECTURES

An on-line lecture consists of a set of electronic slides each with a spoken narrative that is synchronised with any animation, display of supplementary pictures and videos [2]. Figure 1 shows an experimental XML/Java based version of the on-line lecture delivery vehicle. Pictures of two other delivery vehicles are given in [3].

It is constructed using a schematic-based tool [1] that allows text and symbols to be dragged and dropped on to the electronic slides. Circuit and block diagrams are completed using a rubber-band line drawing feature.

Basic revelation, or highlighting, of bullet points are specified with horizontal ‘rule-off’ symbols placed between the bullet points; of course these symbols are not included in the final presentation. More complex animation, for example, pointing to a specific symbol in a diagram or showing the step-by-step construction of a diagram is specified using a sequence of slides. Copying of slides and the alignment between slides are straightforward operations.

The spoken narrative is recorded in sound bites generally between one and four sentences in length. These spoken paragraphs usually constitute a complete concept. To these are attached dynamic hyperlinks whose symbols are placed in a left-to-right, top-to-bottom order on the electronic slide; this positioning specifies the order in which they are to be played. Again the hyperlink symbols are not included in the final presentation.

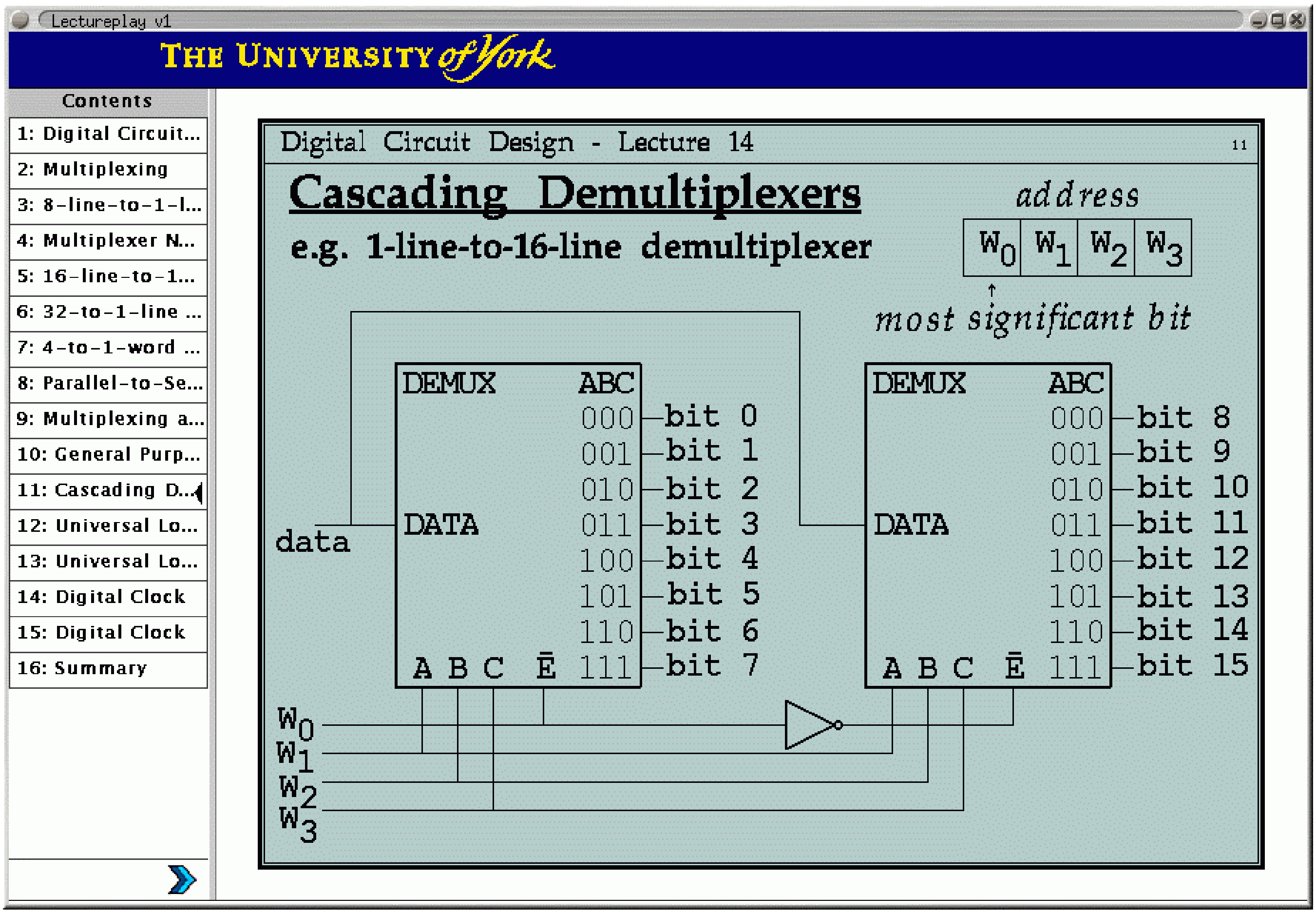

FIGURE. 1
ON-LINE LECTURE DELIVERY VEHICLE BASED ON XML/JAVA

With the lecture metaphor in mind the teacher constructs slides that are to be projected and adds the animation, supplementary material and the spoken narrative. The lecture is then generated. Certain advantages accrue from this approach. First, it encourages careful thought about precisely what should be said at each stage of the lecture, and because the narrative is usually scripted, and then rehearsed before recording, the lecturer has time to dwell on what is going to be said and ensure that nothing important is left unsaid. In this way, spontaneous off-the-cuff remarks are practised, just as a professional comedian might do. Furthermore if there are any hesitations or 'ums's' then they are deliberately there to give effect.

In engineering disciplines, diagrams do have to be complex sometimes so as to give a good overview and ensure that students do not ponder over detail that is left out for the sake of clarity. In these circumstances animation showing the construction of the diagram can provide both overview clarity and confirmatory detail. Whether such diagrams should be created, ought not to be determined by the complexity of the system used to create them!

Although picture and video shows within a slide may be specified to run in parallel with the audio, animation always takes place in sequence with the audio, one after the other. This is so that animation itself can convey information, undisturbed by the information given aurally [5]. While it appears that humans can attend to both the aural and visual channels simultaneously, actually the human's focus of attention needs to be switched between them [6]. For picture shows with parallel audio, the presentation time is determined by the length of the audio fragment. Each picture is given equal display time unless the lecturer has specified an extra wait period for some of the pictures.

LECTURE THEATRE DELIVERY

An overhead projector (OHP) usually showing computer generated view-foils provides a crisp, clear and bright display of material to augment the lecture. With the aid of a piece of paper, items on the view-foil may be covered and gradually revealed as the story unfolds, keeping the audience synchronised with the current point. The strong light that shows through the paper enables the lecturer to view what is coming before it is revealed to the audience. This acts as a cue which invokes the joining remark needed to cover the move from the current point to the next. However for some in the audience, the covering up is regarded as an irritation because they cannot read ahead and take notes.

The change of view-foil acts as a rest and re-charge for the audience while the pick-up and brief observation of the next foil cues the lecturer as to the concepts that are to follow. It almost goes without saying that OHPs are available for use immediately on start-up, a boon when the preceding lecture overruns.

OHPs do however have some drawbacks. The need to point at items in a drawing for example ties the lecturer to the projector; if a laser pointer is adopted then the shaky spot fails to point out the item under consideration and requires the lecturer to face away from the audience. There is also no opportunity for animation; and the display of supplementary pictures, video and the playing of illustrative music or speech is achieved through three further separate devices, all of which have different controllers whose user-interfaces interfere with the flow of the lecture.

With direct computer projection, animation and all supplementary material may be visually and audibly integrated. However, there are points to be noted. First the display is not usually as bright and crisp as the OHP. Second a thumb operated controller should be used to signal the change in display; it should not have an umbilical cord and it should not have to be aimed in order for it to work. Then the lecturer can move around the auditorium using body language to enliven the presentation; the single button requires little cognitive effort for its manipulation. However, given that multiple thumb presses might happen by mistake, a button to undo the last thumb press should be available on the control. Third, the response to the thumb press should be almost immediate and the short delay should be consistent otherwise the lecturer might believe the button was not pressed hard enough and press again eventually causing the display to get ahead of the lecturer. Fourth, what is coming next for the audience, must be known to the lecturer so that the presentation can progress without any hesitation. Thus prior visual signals need to be generated to cue the lecturer as to what is coming next in the sequence after the thumb button has been pressed. The indicative symbol is placed in a fixed area; each symbol is visually and positionally unique providing three cues (including colour) that ought to be recognised quickly, without interfering with the flow of the presentation. The frame advance and highlight are similar in nature and so are located in the same position and have the same overall colour; their detail reflects their difference. The basic functions are shown in Table I and the visual signals are shown in Figure 2. The XML Document Type Definition (DTD) is given in Figure 3.

The SLIDE function must be seen to change the display, particularly if one slide is similar to the next. This signals a change in topic and/or enables the audience to pause their information intake. Prior to the change in slide, the lecturer must be forewarned of a change in topic.

TABLE I
FUNCTIONS NECESSARY FOR GENERIC LECTURE THEATRE DELIVERY

Function	Action	Temporal Issue	Prior Visual Signal
SLIDE	Change to this slide	Change must be perceived	Necessary
HIGHLIGHT	Remove current highlight before highlighting new current point	Change must visually travel down	Inherent
ANIMATE	Step through a sequence of frames	One second step rate	Necessary
PICTURE	Show picture centred in slide	Appears within one second	Necessary
VIDEO	Show video centred in slide	Starts within one second	Necessary
AUDIO	Play audio	Starts within one second	Necessary

The HIGHLIGHT function supports bullet point style presentations in which nothing is actually removed from the screen. Note that there is no support for flying in text; highlighting instead serves the dual purpose of synchronising the audience and enabling the lecturer to see ahead.

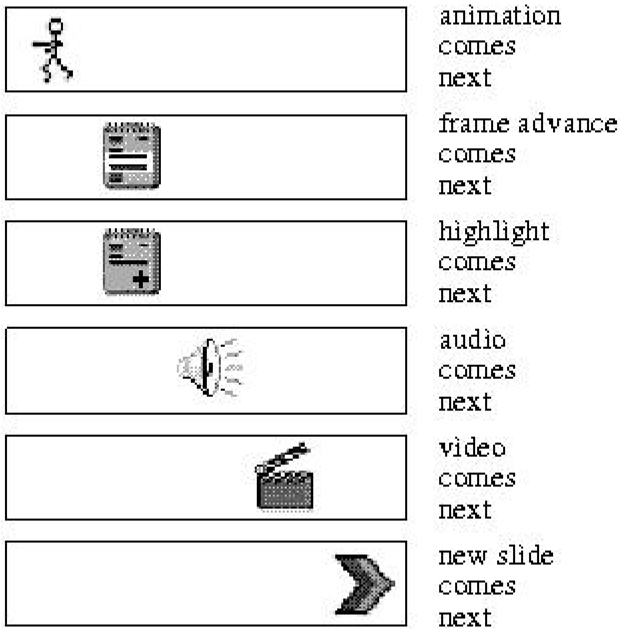

FIGURE. 2
SYMBOLS USED TO SIGNAL WHAT IS COMING NEXT

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<!ELEMENT  LECTURE     (HEADER,FILES,SLIDE+)>
<!ELEMENT  LHEADER   (TITLE,AUTHOR,CREATEDDATE?,
                      REVISEDDATE?,
                      COURSE,LONGCOMMENT?,
                      SLIDECOUNT?,PREVIEWIMG?)>
<!ELEMENT  LFILES      (BANNERIMAGE?)>
<!ELEMENT  BANNERIMAGE (#PCDATA)>
<!ELEMENT  SLIDE       (HEADER,FILES,SEQUENCE)>

<!ENTITY % enumerable-attributes "
        id    CDATA #IMPLIED
">
<!ENTITY % date-attributes "
        day   CDATA #REQUIRED
        month CDATA #REQUIRED
        year  CDATA #REQUIRED
">
 <!ATTLIST SLIDE     %enumerable-attributes;>

<!-- ***************** Fields in HEADER *** -->
<!ELEMENT  TITLE       (#PCDATA)>
<!ELEMENT  AUTHOR      (#PCDATA)>
<!ELEMENT  CREATEDDATE EMPTY>
 <!ATTLIST CREATEDDATE %date-attributes;>
<!ELEMENT  REVISEDDATE EMPTY>
 <!ATTLIST REVISEDDATE %date-attributes;>
<!ELEMENT  COURSE      (#PCDATA)>
<!ELEMENT  LONGCOMMENT (#PCDATA)>
<!ELEMENT  SLIDECOUNT  (#PCDATA)>
<!ELEMENT  PREVIEWIMG  (#PCDATA)>
<!-- ***************** Fields in SLIDE **** -->
<!ELEMENT HEADER       (TITLE,EXTENDED?)>
<!ELEMENT EXTENDED     (#PCDATA)>

<!ELEMENT FILES
(BASEIMAGE,(SOUND|VIDEO|ANIM)*)>
<!ELEMENT BASEIMAGE    (#PCDATA)>
<!ELEMENT SOUND        (#PCDATA)>
 <!ATTLIST SOUND    %enumerable-attributes;>
<!ELEMENT VIDEO        (#PCDATA)>
 <!ATTLIST VIDEO    %enumerable-attributes;>
<!ELEMENT ANIM         (FRAME+)>
 <!ATTLIST ANIM     %enumerable-attributes;>
<!ELEMENT FRAME        (#PCDATA)>
 <!ATTLIST FRAME    %enumerable-attributes;>

<!ELEMENT SEQUENCE
((WAIT|DRAW|SPEAK|SHOW|HILIGHT|PLAY)+)>
<!ELEMENT WAIT         EMPTY>
<!ELEMENT DRAW         EMPTY>
<!ELEMENT SPEAK        EMPTY>
<!ELEMENT SHOW         EMPTY>
<!ELEMENT HILIGHT      EMPTY>
<!ELEMENT PLAY         EMPTY>
<!ATTLIST WAIT    delay      CDATA #REQUIRED>
<!ATTLIST DRAW    frame      CDATA #REQUIRED
                  anim       CDATA #IMPLIED>
<!ATTLIST SPEAK   sound      CDATA #REQUIRED>
<!ATTLIST SHOW    video      CDATA #REQUIRED
                  originx    CDATA #IMPLIED
                  originy    CDATA #IMPLIED
                  maxwidth   CDATA #IMPLIED
                  minwidth   CDATA #IMPLIED>

<!ATTLIST HILIGHT whitesubst CDATA #REQUIRED
                  blacksubst CDATA #REQUIRED
                  top        CDATA #REQUIRED
                  left       CDATA #REQUIRED
                  width      CDATA #REQUIRED
                  height     CDATA #REQUIRED>
<!ATTLIST PLAY    sound      CDATA #REQUIRED>
```

FIGURE. 3
XML DOCUMENT TYPE DEFINITION (DTD)

The ANIMATE function provides for a sequence of changes to the display. Animation is designed to be a visual means of supplying sequential information; it is not designed for some cinema character, for example, pointlessly to walk about the slide. The audience need to be able to absorb the steps in the sequence rather than simply and (too) quickly see the sequence. But if the sequence is too slow, the sequential information will not be absorbed. A rate of between half and one second between frames is about right and must be the same on all delivery platforms now and in the future. When the concept is difficult, the animation can be repeated or be displayed as a set of sequential steps allowing the lecturer to reinforce orally what is being demonstrated between each step.

The display of a picture (PICTURE), the start of a video (VIDEO) or piece of music (AUDIO) needs to begin within one to two seconds and once started there should be no perceived hesitation in the audio or video. It is unacceptable to have start times greater than two seconds and this user-interface requirement places a heavy demand on the technology. For VIDEO, one thumb press brings up the first frame, the next button press causes it to play until it finishes and leaves the final frame on display. This is removed on the next button press.

DISTANCE LEARNING DELIVERY

For learning at a distance or during private study, the whole presentation sequence needs to be available as if it were a video, with the ability to navigate non-linearly and quickly to specific slides and sequences. Temporal delays are an important aspect when conveying taught information because they either help to reinforce the linking of ideas or confirm the change in narrative direction [7]. While these necessary delays are of the order of one to three seconds, it is essential that the student can perceive differences in the delays. Thus, the tolerancing of the timing places a further demand on the technology. It is important that the student can perceive the difference between a short delay (about one and a half seconds) and a long delay (about three seconds); otherwise the visual message (of association or dissociation) will conflict with the narrative. These delays need to be inherent in the delivery system, the lecturer should not need to specify them. Furthermore, the delays must be the same on all delivery platforms. It is also important to realise that a three second delay is close to the maximum time (about four seconds) when most people will start to demand a response from the computer (by pressing keyboard keys at random). Table II shows the temporal sequence for the functions available in the specification. All functions will follow each other with the correct level of association/dissociation.

If a painting is to be discussed, the important features would be indicated in the narrative. But paintings need time to be absorbed quietly and so longer delays, perhaps up to thirty seconds, may need to be specified. In such cases the author of the lecture must forewarn the student that this reflective time has been incorporated in the presentation. As more time than thirty seconds is desirable, the picture should be accessible by some other interactive means.

Function	Sequence
SLIDE	Short pause Change Short pause
HIGHLIGHT	Change Long pause
SPEECH	Play speech Short pause
ANIMATION SEQUENCE	Change frame Short pause Change frame . . Long pause
PICTURE	Display Long pause
VIDEO, AUDIO	Play Long pause
WAIT	Wait

TABLE II
FUNCTIONS AND TEMPORAL ACTIVITY FOR SUPPORTING PRIVATE STUDY

QUALITY OF SERVICE

The foregoing has indicated that the delivery vehicle must determine and control quite accurately the delays in the presentation. Today the technology is sufficient to ensure that accessing image, video and audio files via a local area network or from a local disc will not have an adverse impact on those delays. However, if the files are obtained from a CD-ROM or over the internet with their attendant high latency and low bandwidth specifications, then delays will be highly variable and may cause incorrect semantic associations. Thus a cache, populated and maintained by a pre-load thread is necessary. Image files need to be available in a time T, determined by the inequality given in (1), before they are needed for display.

$$T \geq latency + \frac{filesize}{bandwidth} \quad (1)$$

Where latency is that of the storage device, and bandwidth is that of the transmission medium from the storage device to the display. It is important that the content defines the delays, not the technology!

CONCLUSIONS AND FUTURE WORK

This paper has described the rationale underpinning the design of an XML/Java based delivery vehicle suitable for presenting on-line lectures both in the lecture theatre and during private study. It has argued that the features must be simple to specify (perhaps with the aid of an interactive tool) without the need to understand the complex temporal user-interface issues. The need for the file format to be in the public domain is essential if the lectures are to be searchable by learning support tools.

The Document Type Definition (DTD) shown in Figure 3 indicates that extra information may be specified such as lecture and slide titles, dates, etc., and these would be used by any search mechanism. This needs to be extended to accommodate the searching of the narrative scripts and diagrams.

An additional module based DTD is required to provide an index to those lectures and additional multimedia documents that constitute the module’s material. The search tool might then use this index to build its working files.

As the SMIL definition matures, future work might also provide a conversion tool to create a SMIL version of the on-line lectures.

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