Adaptive Virtualisation for Multi Modal Learning Objects

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Abstract - **Work by the writers has investigated validation methods for creation and manipulation of multi modal learning objects in an adaptive Virtual Learning Environment (VLE) presentation system. This paper investigates the requirements for a robust, autonomous, virtual infrastructure needed to simulate novel adaptive methods based on fragmentation and routing algorithms like OSPF. Evaluation is done of virtualised processes adapted on a software router in a known infrastructure. Adaption is achieved with operations performed on the metadata of learning object fragments rather than link states. Execution of such models in a 'Semantic Ontology Engine' is proposed as an approach to the creation of a cloud computing based semantic multimedia VLE, offering better personalisation. The findings emerge by means of a comparison of simulation results of virtual network components.**

Keywords – ***e-learning, adaptive, semantic, ontology.***

I. INTRODUCTION

Previously, an Adaptive Multimedia Presentation System (AMPS) has been proposed with semi-automated tools for adapting stored computer based learning objects to students' learning needs [1]. It was concluded that a novel, autonomous 'Semantic Ontology Engine' is needed as a key building block to process learning objects by performing decomposition, fragmentation and re-composition. However, a very important research question remained unanswered - how to approach the validation of multimedia structures built by autonomous semantic processes in a VLE, without the services of a human tutor to evaluate 'true' fragments of learning.

An experimental approach will be taken to verify the efficacy of the required semantic ontology function. The operational approach employed in this paper starts with a survey of various pre-existing virtual network simulation tools that are expected to offer at a partial solution to the problematic evaluation and verification of metadata models that satisfy these complex requirements [2]. The resulting tool promises to be an experimental virtual infrastructure capable of executing multiple, proposed semantic models of ontology engines, each capable of manipulating and validating learning objects in a Cloud-based Adaptive Virtual Environment (CAVE) potentially without a human tutor.

Hence, in this paper steps in our research programme are set out to provide robust evaluation of a suitable model for the semantic ontology engine based on an analogy with network routing protocols. In se ction II, a comparison between computer networking routing concepts and the requirements for an ontology mapping based on an ontology calculus is set out. In section III, features of some virtual simulation tools are compared in detail. These are commercial products or open source from educational institutions, with a mixture of local and remotely accessible options. Although the review is far from exhaustive, it includes some well-known and recently introduced packages. After the review of features, one tool is selected for comparison with an actual physical network; Section IV gives the results of this comparison for two scenarios; Section V is an analysis of findings. Finally, Section VI gives conclusions about applications of virtualised networks simulators to learning objects.

II. A COMPARISON OF ROUTING CONCEPTS AND AN ONTOLOGY MAPPING

One of the primary functions of the ontology engine will be to retrieve the learning objects for delivery to the student, in the sequence in which they will be presented. There is unresolved discussion about the most appropriate method to achieve this. One approach is the object oriented modelling approach of Lee & Chung [21]. We propose a new approach based on concepts which are already successfully used in computer networking. It suggests that the concepts used in the selection of the 'best path' determined by router network devices in a computer network between two nodes carrying traffic on a digital network may be used as an appropriate analogy for learning object retrieval from an ontology network.

A. Pathway Determination

A key feature of an adaptive learning delivery system is a process for the selection of learning materials appropriate to the required learning, and suitable for the learning level and style of the individual student. In computer networking, the selection of the best path for traffic delivery is made according to metrics such as 'hop count' and 'bandwidth'. This process is successful at delivering electronic data worldwide and operating at optimum speed within the constraints of the hardware available, whatever that may be. The hop count is the

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number of 'hops' to other routers required to reach the destination. As distance is measured in terms of hops, rather than physical distance, the shortest distance is that with the lowest hop count. Bandwidth is the data capacity of a link defined in terms of bits per second that can be transmitted over the medium. Both are useful indicators of speed of delivery. In a virtual learning environment similar metrics can be applied such as the distance attribute described in our developing ontology calculus. In networking, the selection of the path taken by data is determined by a device which connects separate networks together known as a router. This device makes decisions about routes for each packet of data it receives, and that decision making process is completed in fractions of a second. The high speed is made possible by the narrowing of options. Rather than determining the whole path at the beginning of the journey, only the next hop is selected. At each router the options are narrowed only to the other networks which are physically connected.

In our model, the learning objects are likened to the nodes of a network that needs to be traversed by the student who is seeking to learn a particular subject domain. Learning objects are like the routers of a network. Though they have no physical connections they are connected logically through the ontology. In the same way as a network can be mapped, an ontology provides a map of the relationships between topics. A model of this is described in Davies et al. [22]. Rather than sifting through all available learning object segments for related material, using the metadata in the learning objects, their position within an ontology can be determined at the point of implementation. When required, the selection of learning objects for presentation can be narrowed down to other closely related material. Where selection by searching all materials may add a significant time delay, searching only closely related materials should be relatively fast.

B. *Delivery Methods*

Once materials have been selected, the next stage is delivery to students. E-learning should be extended so that it is deliverable anywhere and everywhere. This is called ubiquitous learning or u-learning. Delivery methods must take into account the destination client device when presenting learning objects for delivery in a virtual environment, for example, a pc or a mobile phone.

In computer networks, routers handle packets containing data. The packets are conceptually an outer wrapper, allowing packets to be unwrapped and rewrapped with new addressing information without disturbing the data itself. In fact, there are many layers wrapped around the data in a networking scenario. Each layer contains different pieces of additional data and at several different layers there may be different kinds of addressing information. Since only the hop to the next router is determined when selecting a route through the network during transit, the outer layer is removed at a router and the data rewrapped with the address of the next destination device. The address of the final destination is kept at another layer undisturbed by this process.

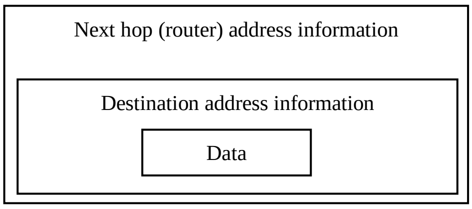

Figure 1. Model of a frame and some conceptual layers in computer networking

The outermost layer contains addressing information and its format is determined by the media on which the frame has to travel. Similarly, in a course delivery system, a wrapper around the learning object would determine to whom it will be presented, when it will be presented and in which order it will be presented. If a learning object is to be presented to a particular student then the student signature represents the address to which that learning object is to be delivered.

TABLE 1. ASSOCIATIONS BETWEEN GRAPH THEORY, NETWORKING AND ONTOLOGY DESCRIPTIONS

Graph Theory	Networking	Ontology
Node	Router	Learning Object
Link	Connection	Relationship
Node location	IP address	Learning object identifier
Algorithm	Protocol	Order of presentation
n/a	Wrapper	Student Signature + other determinants (metadata)

C. *Delivery format*

The format of the information is determined by the destination client platform. If the page is to be displayed on a pc then a full size web page constructed of html, xml and other web technologies is wrapped around the learning object. If the student is learning on a mobile phone then suitable technologies are required to display a page to suit the small screen size and these will wrap around the learning object before it is sent to the student's learning platform of choice. Connection speeds may also be a metric for changing what is sent.

Connection speeds may go so far as to affect the learning object itself. There is little point in trying to download a high resolution image of great size down a slow connection to a small phone screen. Perhaps enhanced versions (e.g., HD or 3D images) would benefit the student using a larger screen. Therefore, each learning object may be required to consist of different versions of the media file.

Therefore, as when using the Transport Control Protocol in digital networking, an initial exchange of information between the client and server devices to request, and then supply client platform specification in terms of both hardware and software must take place.

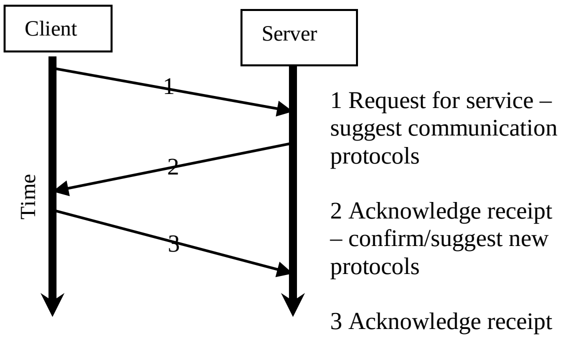

Figure 2. TCP 3 way handshake at start of communication session

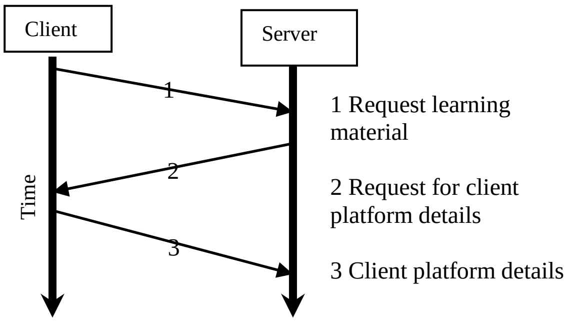

Figure 3. System 3 way handshake at start of learning session

Possibilities for required different formats are enormous and ever changing, such as different resolutions for images and video, different compression rates for audio, and different formatting for text e.g., transforming a document from a word processor into html to improve compatibility. Generating these additional files for each object impacts the authorship work load significantly. The high level of investment required for production of quality learning objects has been an issue since they came about as discussed by Boyle [18]. Dynamically generating suitable versions from high quality originals is a preferred option to increasing storage requirements and second guessing possible future platforms.

The investment in authorship workload will mean that writers are keen to reuse a learning object in more than one area and so its upload to the system requires additional consideration. Contextualization of the learning object becomes an important consideration if re-use is high. This will involve the creation of metadata categories to capture the contextualized data. The IEEE 1484.12.1 - 2002 Standard for Learning Object Metadata [3] is an internationally recognized open standard for the description of learning objects. Attributes of learning objects included could be the type of object, author, owner, terms of distribution, format, as well as pedagogical attributes, such as levels of difficulty or student learning styles. A set of these attributes need extension to include context.

Indzhov et al. [19] explain users of such systems are often poor at completing metadata requirements. Being able to position the object in an ontology map of the knowledge domain would aid this process. Ideally, the metadata for a learning object, where possible should be automatically generated. Bauer et al. [17] discuss the possibility of collaborative tagging relying as it does on a large enough, and knowledgeable enough audience to complete the tagging before use of the semantics within the system becomes essential, and so time is required to carry out 'tagging' before the object itself is useable. Automatic metadata generation is a mature development area. For instance, if an object contains images much work has been done in the area of identifying objects in images by many including very recently Amir et al. [16]. As a result others have studied the composition of the resulting information into metadata that can be used with learning objects. Cardinaels et al. [20] developed a indexing interface for automatic meta data generation, and more recently Bauer et al. [17] surveyed the tools available to do the job and compared them.

Metadata can conceptually be perceived as another layer wrapped around the learning object. Indzhov et al. [19] discuss using the results of tests for calibrating the difficulty levels and usefulness of learning objects, as well as the possibility of assessment question generation from metadata. By using metadata as a wrapper on the outer layer of the learning object, it can be read and updated without disturbing the object itself.

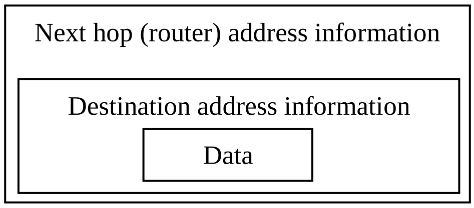

Figure 4. Model of a frame and some conceptual layers in computer networking.

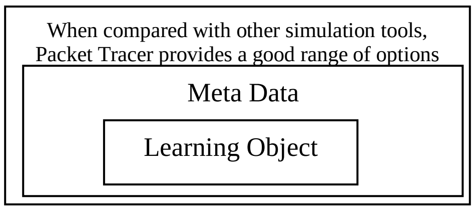

Figure 5. Model of the learning object wrapped in required implementation layers

III. Network Simulation and Comparison of Virtual Routers

We now turn to a network analogy in more detail and consider a closer examination of networking simulation tools provides insights into tools useful for modelling an ontology engine to process ontology networks and determine the validity of learning pathways.

Due to its nature, discrete event is a method of simulation suitable for modelling systems where processes act on discrete units, for example a data packet in a communications network, a job on a production line. This type of layered operation is important in most types of data communications and networked system. It has been acknowledged that networks such as these are complex in their design and operation. As such, simulation is an important tool for designing and operating these networks.

For modelling computer networks discrete event simulation is the popular choice although other techniques are also used. There are many simulation tools for this task. For this reason there have been many papers written that have reviewed and compared these tools and packages. Most of these papers have studied the tools from the point of view of their usage and suitability for different tasks. This paper intends to look more closely at how some of these tools accomplish what they do, with a view to adapting network simulation techniques to adaptive learning techniques.

Simulation tool packages are well represented in the literature and classified into four main branches shown in Figure 6.

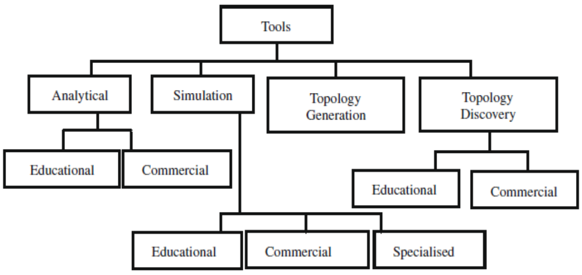

Figure 6. Tool Packages

These categories are quite broad. This paper is concerned with tools for educational and learning activities in VLE. It has been acknowledged by a number of sources that learning the skills required to design and manage computer networks requires practical experience in addition to a theoretical base.

The advantages of visualisation compared with providing physical facilities are well known. Use of simulation tools to create virtual lab environments provides an opportunity to increase access at a lower cost than physical equipment, offering the possibility to carry out more complex experiments than would otherwise be possible.

IV. RESULTS OF THIS COMPARISON FOR SPECIFIC SIMULATORS

We now examine two particular systems to illustrate the range of usage and properties available.

D. Packet Tracer

Cisco Systems has produced Packet Tracer [23] as an educational tool for their network academy program to assist students with their studies for qualifications such as CCNA. It provides many features to assist both students and instructors in the field of network design and maintenance/management. Features include the ability for the instructor to create lab scenarios for students to complete, also included within this is the ability to assess the students. Beyond these preconfigured networks and activities, Packet Tracer also allows the creation of any possible topology that can be built using the available pallet of hardware.

When simulating the network that is being studied there are two options for interaction. The first is real-time; in this network reacts as a real-world system would, for example if you ping one device from another this would occur at realistic speed. The second option for simulation, described as simulation mode by Cisco, allows the user to slow down the operation of the network to see the movement of data packets that are visually displayed on the network diagram (Figure 21). The speed of this animation is controllable as is how quickly it moves to each event. This can occur automatically based on the speed or can be made manually, allowing students to see the movement of data packets within the network.

E. OPNET

OPNET [24] is a commercial research and development package developed by OPNET systems that is popular in both research and commercial applications. It provides the ability to model wired and wireless networks and their interactions using a large library of models provided, and also allows the user to modify or create their own. These models are created using C++ programming language and the source code is included for the models provided.

Additionally, the ability to customise the models when running simulations in OPNET it is possible to vary the level of detail of each simulation run dependent on the requirements of the application. To accomplish this, OPNET provides three methods of simulation.

The first option, giving the highest level, of detail uses discrete event driven simulation OPNET implementation of this comes in two forms. The first being sequential were all tasks performed a linear fashion on a single processor, the second form parallel distributes the tasks over multiple processors which can be part of the same system for distributing over multiple interconnected systems. This latter parallel system improves performance by spreading the work allowing for faster simulations. There are also additional optimisation options provided for the discrete event simulation. The second option, flow analysis(tm) uses analytical modelling to provide a faster but less detailed simulation, ideal for the use with simulation large networks and repetitive scenarios such as modelling the effect of failures on traffic with the network where it is necessary to run many iterations of simulation. The third option is a hybrid of the first two techniques allowing for balance of speed and detail within one simulation.

These methods coupled with the large library of simulation models allow the OPNET user to create networks varying from a small office all the way up to world-wide communication systems.

F. GNS3

GNS3 [25] is an open source package created to allow users to practice configuring Cisco Systems networking devices in a realistic environment without the need to purchase expensive equipment. This has been accomplished by emulating the heart of a number of such devices. In turn this allows the user to run genuine software from the device on a normal computer system. Although the emulation provides a comprehensive set of hardware features it cannot provide the same speed of response times as the real equipment. The biggest drawback for this package is that it does not support many newer devices as these use proprietary integrated circuits that so far, and probably never will be emulated in software. There are moreover also changes occurring in the newer versions of Cisco's software that will change its licensing mechanism, requiring activation beforehand, thus preventing unauthorised installation and use .

V. ANALYSIS OF FINDINGS.

Although the above systems by no means constitute an exhaustive c exploration of the available solutions, it has considered some of the most popular and new options. Each of these tools has its own advantages and in many cases its own niche in the market. It is not possible to make a sweeping conclusion about which tool is best as each tool has its own place and time. For example, for a beginner to networking Packet Tracer is ideal, but for a researcher studying performance of wireless networks OPNET could be the tool of choice.

Table 2 shows a comparison of simulators including tools for which there was insufficient space to discuss in detail here.

VI. CONCLUSIONS AND FUTURE WORK

Investigations into network simulation tools indicate that there is scope to consider the use of routing algorithms for suggesting analogous models for routing learning objects to determine a specific learning pathway to specific students.

To take this work further we need to construct a full, robust tutor model to automate the learning object segmentation process, an investigation of structure of metadata and a detailed construction of the student model to include the student signature which will directly apply the learning-routing algorithm as a wrapper on the learning object. Our vision is to build this into a novel abstract conceptual data model encompassing all the properties that are needed to make explicit the qualities of an effective adaptive learning system. In this event Critical Success Factors (CSFs) would play a central role

TABLE 2. COMPARISON OF NETWORK SIMULATORS

								Supported technologies		
	Remote access	Vendor specific	Hardware based	Simulation based	GUI	Assessment tools	Network topology	Routing	Switching	wireless
Packet Tracer	No	Yes: Cisco systems	No	Yes	Yes	yes	User defined	Yes	Yes	Yes
OP Net	No	No	No	Yes	Yes	No	User defined	Yes	Yes	Yes
GNS 3	No	Yes:Cisco systems & Juniper	No	Yes	Yes	No	User defined	Yes	Partial	No
VELNET	Yes	No	No	Yes	Yes	No	User defined within limits of simulation	Yes	No	No
Remote Access internet work lab	Yes	No	Yes	No	No**	No	User defined but limited to available equipment	Yes	Yes	No
A Virtual network lab for learning ip networking	Yes	No	Yes	No	Yes	No	Pre set	Yes	Yes	No
An integrated structure for virtual networking lab	Yes	Yes :Cisco systems	Yes	Yes	Yes	Yes	Pre set in hardware for remote lab but user defined for local simulation	Yes	Yes	No*
Virtual Network lab(VNL)	Yes	No	Yes	No	?	No	Pre set	Yes	Yes	No
NetLab+	Yes	Yes :Cisco systems	Yes	No	Yes	No	User defined &some pre set avalible	Yes	Yes	No
IOU	Yes	Yes :Cisco systems	No	Yes	No	No	User defined	Yes	No	No
L2IOU	Yes	Yes :Cisco systems	No	Yes	No	No	User defined	Yes***	Yes	No

[illegible] available for local simulation **[illegible] ***supports Layer three switch functions in determining the choice of the best network software tool needed for the simulation. The introduction of CSFs on which the best network simulation tool will be chosen is left to a future paper.

It is acknowledged that this work is in its preliminary stages. The next step will involve a simulation for specific software tools and simulation in a real environment.

Finally, although work discussed in this paper answered research questions posed in previous papers, it has indicated further questions with a different emphasis: What is the full specification of the ontology required and how is it captured? How should the ontology engine structure be modelled and evaluated? Can fuzzy logic or data mining techniques be candidates for a useful algorithm? And "What further adaptation features are required and how are they to be evaluated?" We leave these questions to a further paper.

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