On Developing of Tools and Platform for Pervasive Multimedia Learning Environment

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Abstract
This paper presents on-going work on providing tools and platform for Pervasive Multimedia Learning Environment. We review the state of the art technology in the field of tele-education, particularly on CSCW tools, pervasive computing, network performance management and measurement, active networks technology and applications, and mobile IP. We develop an infrastructure called Friendly Active Network System (FANS) which uses the active-network paradigm to perform bandwidth adaptation for heterogeneous bandwidth requirements by monitoring the bandwidth capacity of the peer computers and takes appropriate bandwidth adaptation strategy based on bandwidth information. Content-wise, we are developing a Passenger-UML which is a Computer Supported Collaborative Work (CSCW) tool to support Computer Aided Software Engineering (CASE) based on the latest Unifield Modelling Language (UML) approach. As supporting components we have been prototyping pervasive environment and a testbed for multimedia mobile IP support.

Keywords: Pervasive Environment, Multimedia Learning, Active Networks, Heterogeneous Bandwidth Environment, Multimedia Mobile IP

1. Introduction
The development of learning technology has triggered evolution in learning environment. Time and place are the major constrains which create learning barriers. Aiming to overcome the time barrier, learning media has changed from classroom approach to TV or radio program, and through distributed CDs and video cassettes, and finally through mailing list and web-based teaching (any time).

Dealing with barrier in terms of place, learning environment has also evolved from giving lecture at the same place (e.g., classroom) to at some places such as distance learning to some classes at different locations and, finally, to any place, for example virtual class such as distributed and mobile learning through Internet connection to mobile devices. This evolution is depicted in the following Table 1.

<table>
<thead>
<tr>
<th>Boundaries</th>
<th>Media/Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Same time</td>
<td>Classroom</td>
</tr>
<tr>
<td>Some times</td>
<td>TV, Radio</td>
</tr>
<tr>
<td>Any times</td>
<td>Distributed CD, Video Cassettes</td>
</tr>
<tr>
<td>Place</td>
<td></td>
</tr>
<tr>
<td>Same place</td>
<td>Classroom</td>
</tr>
<tr>
<td>Some places</td>
<td>Distance learning, e.g Open University</td>
</tr>
<tr>
<td>Any places</td>
<td>Virtual class (Distributed and mobile learning through the Internet)</td>
</tr>
</tbody>
</table>

In this research we address the prominent technologies to provide facilities for tele-education. Those technologies are pervasive computing, mobile IP active networks and computer supported collaborative works.

2. Multimedia Learning Environment
Our pervasive learning multimedia environment consists of four main components. Those components are audio video tools for teleconference purpose, shared working space to support collaborative works, mobile
IP component to support mobility of users, and pervasive devices to allow access anywhere, anytime and on-demand. The component diagram is shown in Figure 1.

To support the delivery of multimedia content to clients which have heterogeneous bandwidth we use our own active network technique called friendly active networks (FANS). FANS have been developed as an improved active network approach for distributed and dynamic streaming multimedia environment with heterogeneous bandwidth. By addressing the multimedia applications’ streaming through the Internet, FANS supports the distributed learning and access philosophies. The balance between quality, access and cost is accommodated based on the specific need of the partner institutions.

Figure 1. Components of the Environment

3. Active Network Infrastructure

A problem with the current Internet condition is the heterogeneity of clients’ bandwidth capacities. This situation exists throughout the world where universities or education institutes connected through high-speed bandwidth are expected to deliver multi-media teaching session to other universities or institutions with various bandwidth capacities. Delivering a high quality video creates congestion to institutions with poor bandwidth. On the contrary, delivering low quality of video underutilizes the institutions with high bandwidth capacity. The information content of video and audio signals that contain moving or changing scenes may simply be too big for Internet clients with low bandwidth capacity if no adaptation is performed.

There is no simply one quality fits for all bandwidth capacities. Therefore our Friendly Active Network System (FANS) [1, 2] approach is to fairly distribute the quality of video presentation based on the capacity of bandwidth possess by partner institutions. Institutions with high bandwidth capacity receive higher quality of video, whereas institutions with low bandwidth capacity get lower quality of video. However FANS still requires some works to improve its scalability and functionality to support pervasive computing issues and addresses load balancing problems. A sample scenario of FANS is shown in Figure 2.

Figure 2. Sample FANS Scenario

Figure 3 represents the preliminary result of system’s performance. There are three combinations of FANS reroute mechanism and chain of codecs, i.e. H263–H263–JPEG–H263, that overpower the direct connection either with JPEG or H263 codec in terms of the reliability of the streaming media. Out of these three combinations JPEG–JPEG–H263 combination offers the best quality of video presentation.
With JPEG–JPEG–H263 combination the system maintains the quality of video presentation as good as possible until the intermediate peer. It then opts for the efficient mode, i.e. H263 codec for the final stage to adapt to the low capacity of the client’s bandwidth. However streaming media with JPEG codec at intermediate peer, as is the case with JPEG–JPEG–H263, demands that the peer has sufficiently high capacity of bandwidth. H263 codec requires only 300 Kbps of bandwidth to stream smoothly. Therefore although produces less quality of video presentation H263 codec should always be employed in the chain of codec combination if either of source node, intermediate peer or requesting node has only at most 300 Kbps bandwidth.

We notice also that the JPEG–H263–H263 is the most reliable codecs combination to maintain packet lost in an acceptable manner if no other nodes but the source node having high bandwidth capacity. Due to the less than fair quality of video presentation it produces the combination of H263–H263–H263 is only to be considered if the requesting node has less than 100 Kbps bandwidth.

4. Teleconference Components and Tools for Collaborative Work

In addition to the bandwidth allocation problems, to develop an e-learning environment we need a computer supported collaborative works tools which utilize the state of the art technology which provide a fast, efficiently, and reliable connection to bridge differences in facilities. In addition to that the system should also provide a platform that supports geographically distributed students and lecturers.

There is also need for some tools to support education oriented collaborative work. Some tools for synchronous communication such as the publicly available package such as Microsoft Netmeeting or CU-See-Me cater general needs for collaborative work, but insufficient for educational purposes. The tools for synchronous work need to have more functions than publicly available tools, as follows:

• a better support for discussions, the setup of partners images and relationship management.
• mechanisms for preventing communication breakdowns.
• support for the students in their cooperative actions.
At the moment our CSCW tool (Passenger) [3] for software engineering is based on Ward and Mellor structured programming approach. This requires some improvement to cater the newly develop de facto standard of software engineering approach such as UML (Unified Modelling Language) [4]. User interface of the current teleconference and collaborative working tools is shown in Figure 4 above.

5. Design and Modeling of Mobile IP System

We design and implement a testbed based on real scenario in developing mobile IP system for multimedia applications [5]. Based on this scenario we evaluate the reliability and quality of service of the applications. The network topology is designed to represent a simple real condition. The core router in IPv6 backbone is acting as Internet cloud. Home agent has a function to monitor traffic flow and statistical ping-loss that is actualized in Web and graphical format. Access point (AP) is used to bridge cable and wireless network interconnection by utilizing 2.4 GHz teknologi wavelan. Distribution router functions as home or foreign agent, which is developed using zebra routing algorithm. Figure 5 depicts the network topology of our testbed.

Figure 5. Network Topology

The network architecture is designed and developed based on the general element of a mobile IP system. The architecture is considered sufficient for QoS evaluation of multimedia application over mobile IP. It consists of Home Agent/Node, Correspondent Agent/Node, Mobile Agent/Node, and Foreign/Remote Agent/Node. The testbed is configured based the scenario of evaluating QoS for mobile multimedia applications. In this scenario a mobile user is accessing multimedia session while moving. The testbed configuration is depicted in Figure 6.

Figure 6. Mobile IP System Architecture

Mobile node (MN) is represented by laptops. MN accesses a streaming video application over the mobile IP testbed. Distribution router/home agent monitors the mobility of MN through its traffic. The measurement mechanism inside the testbed configuration is depicted in Figure 7.

Figure 7. Testbed Configuration

Presuming that the handover process does not disrupt the streaming of multimedia application, MN moves to the Distribution router/foreign agent on different node. Home agent keep monitoring MN. Core
router/home agent as monitoring element for the activity of MN collects data and measures the QoS of the mobile multimedia application.

There are three measurement points in the system evaluation, namely home cell, inter cell and foreign cell. We measure packet loss, delay, reliability of the connection and the end-to-end throughput between MN and home agent. The schematic diagram for measurement is shown in Figure 8.

![Figure 8. Measurement Mechanism](image)

After completing the testbed implementation and configuration development we measure the QoS. Main observation point the node core router/home agent. Connectivity and reliability of connection between MN and the core router is evaluated and tested continuously when either the MN stays or moves.

Routing test is done by collecting data on each of node that is traversed by home agent monitoring packet when the agent monitors the mobile node. The test is made whether the mobile agent is in home network or in foreign network. Figure 9 depicts the configuration for routing test.

![Figure 9. Routing Test Configuration](image)

The results of routing tests are shown in Table 2 to Table 4.

### Table 2. Connectivity Test

<table>
<thead>
<tr>
<th></th>
<th>CR-HA</th>
<th>Min</th>
<th>Avg</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-HA</td>
<td>0.112</td>
<td>0.119</td>
<td>0.126</td>
<td></td>
</tr>
<tr>
<td>CR-FA</td>
<td>0.317</td>
<td>0.341</td>
<td>0.357</td>
<td></td>
</tr>
<tr>
<td>DR-FA</td>
<td>0.119</td>
<td>0.144</td>
<td>0.151</td>
<td></td>
</tr>
<tr>
<td>MN-HA</td>
<td>1.968</td>
<td>2.033</td>
<td>3.609</td>
<td></td>
</tr>
<tr>
<td>MN-FA</td>
<td>1.966</td>
<td>2.020</td>
<td>7.416</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3. Availability Test

<table>
<thead>
<tr>
<th></th>
<th>Success</th>
<th>Loss</th>
<th>Availability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR-HA</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>CR-FA</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>DR-FA</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>MN-HA</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>MN-FA</td>
<td>99</td>
<td>1</td>
<td>99</td>
</tr>
</tbody>
</table>

### Table 4. Measure with 1025 Bytes Packet

<table>
<thead>
<tr>
<th></th>
<th>CR-HA</th>
<th>Min</th>
<th>Avg</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-HA</td>
<td>0.480</td>
<td>0.489</td>
<td>0.664</td>
<td></td>
</tr>
<tr>
<td>CR-FA</td>
<td>2.048</td>
<td>2.108</td>
<td>2.422</td>
<td></td>
</tr>
<tr>
<td>DR-FA</td>
<td>0.491</td>
<td>0.518</td>
<td>0.683</td>
<td></td>
</tr>
<tr>
<td>MN-HA</td>
<td>0.576</td>
<td>0.685</td>
<td>0.646</td>
<td></td>
</tr>
<tr>
<td>MN-FA</td>
<td>0.618</td>
<td>0.710</td>
<td>0.720</td>
<td></td>
</tr>
</tbody>
</table>
It can be seen from the measurement that the movement of MN affects the duration of packet delivery. The longer the distance of the movement the more nodes are traversed, and the longer the duration. When MN moves we note the loss of connectivity for one time, and we consider this within reliable limit.

6. Prototyping Pervasive Environment

With the advancement of the Internet and Networking technology, there are challenges and need to provide educational opportunities at any time and any place. Pervasive computing is a promising technology to accomplish this requirement. The deployment of the combined tools and platform such as passenger-UML, pervasive computing and active networks application to tele-education will contribute to distance learning technology. Pervasive computing technology is used to extend the accessibility and to support the mobility of students and lectures. It supports the notion of learning everywhere anytime.

We have been developing a prototype of pervasive room or smart home, called Sahara [6], since October 2003. The system is designed and implemented as smart room with pervasive approach. Sahara has various functionalities such as security, control, monitoring, information center, and communication function. The description of Sahara multi-functions is described below.

Sahara is a complex integration of hardware and software. Its implementation involves system level engineering stage. Sahara architecture is depicted in Figure 10.

Sahara is designed and implemented based on pervasive concept. It consists of three main components to fulfill the smart room and pervasive requirements. Those components are internal network, intelligent control and automation part.

Sahara uses cable and wireless medium to connect sensors and detectors to central and independent controllers. Connection between controllers is managed by a computer through serial and parallel ports. Computer connects outside world through PSTN and Internet.

Sahara utilizes computers as central system management and gateway to outside world. All Sahara components are dictated and activated by coordinated micro-controllers, sensors and detectors. Sahara works as security, measurement, monitoring and controlling system. Sahara information and communication system can be accessed inside and outside home.

Interfaces that connect Sahara components and users are shown in Figure 11 and Figure 12 respectively. This interface is very important, since it potentially encourages users to use the system conveniently and easily.

7. Discussions

We have a background work on these four areas, which can be defined as FANS (Friendly Active Network System), Passenger (A Tool for Practical Training and Computer Supported Collaborative Software Engineering), prototyping of pervasive environment, and mobile IP design and modeling. Pervasive
computing, or known as location-aware computing, in which information and communication technology will be an integrated part of our environments. In some cases, a pervasive computing environment has some integrated processors, sensors, and actuators connected via high-speed networks and combined with new visualization devices ranging from projections directly into the eye to large panorama displays.

Figure 6. Main Menu of SAHARA

Figure 8. SAHARA in Action

The intended contributions of our research work are three-folds:

- The provision and verification of a multimedia system that is capable of streaming multimedia applications to peers with heterogeneous bandwidth capability.
- The provision and verification of a system that is capable of carrying out software engineering laboratory practice to geographically distributed students and lecturers or tutors. The collaborative software engineering tools called PASSENGER.
- The provision and verification of pervasive system with dynamic IP to support mobile students to access learning materials virtually and remotely joint on-going lecture.

The joint research group is concentrating on the topics of knowledge-based Internet Systems and Internet Communication technologies. Active Network technology is selected due to the fact that the international joint research groups have different bandwidth capacities in exchanging audio and video streams. Therefore, active network will be the new technology to be applied at the application layer to adapt the streaming traffic to the different bandwidth capacities.
8. Summary

It can be summarized that our on-going work are aiming to the use of new Internet applications into tele-education. The following products are expected to be produced during the research period: The New Passenger UML CASE tool, which support collaborative working environment with multicasting, video and audio streaming capabilities and the improved version of FANS, which includes pervasive computing facilities and mobile IP support.

The multiplier effect of the system is the provision of high quality international-based learning environment which will strengthen the teaching and learning process and encourage the human resources competitiveness. In higher education a lot of changes are stimulated by the Internet and by other enabling technologies which have reduced geographical and time boundaries. The pedagogy of on-line learning is still in its infancy and a lot of areas are to be improved. The tools and platform provided will strengthen educational process, which could be used as a prototype which could help the teaching and learning in Indonesia.

The smart class, CSCW, CASE tools and network platform will support the development of knowledge based society. The virtual class and computer based collaborative work will strengthen the quality and increase the number of capable human resources involved. In other words the research process and result will improve of the quality and quantity of the national information and products. It can be stated that this research is highly compatible with global trends which cover new software.

7. Acknowledgment

Our research on Pervasive Multimedia Learning Environment has been funded by the Ministry of Research and Technology of the Republic of Indonesia through its RUTI-III grant under the contract number 24A/SP/RUTI/KRT/IV/2004. Passenger was first developed by our partners from Institute for Multimedia and Software Engineering, Universitaet Duisburg-Essen, Germany. They grant us permission to develop Passenger-UML.

References