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Multimedia Synchronization Protocol Dedicated for Virtual Classrooms over Narrowband networks

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Abstract

This paper is presenting design and implementation of web based e-learning synchronization protocol. The protocol is HTTP/TCP based and specifically designed to increase the cognitive productivity of learning session conducted over the internet in analogous scheme to real classroom interaction.

The presenting protocol is holding an innovative technique to enhance the performance of broadcasting whiteboards and classrooms to distributed students over narrowband networks. In narrowband networks race condition is raised between multimedia streams in gaining network bandwidth.

Throughout presented protocol; multimedia streams are packetized and synchronized in a compatible model for the cognitive natural learning mechanisms for the human being where actions drag attention and continuous interaction maintain the focus.

Keywords: virtual class, WebSocket, HTML5, Servlet, HTTP, JSpeex, Whiteboard CODEC, e-learning, synchronous and Asynchronous learning

1- Introduction

The concept of Virtual Class developed in the mid-1980 [1] with the idea that student and teachers in different places could come together synchronously with the aid of computer and telecommunications.[1][2]

The virtual classroom allows organizations to provide training courses at a lower cost due to reduced travel time, costs, less time away from the job, faster deployment of time-urgent knowledge and skills and higher completion rates compared to self-study e-learning. [1][3][4]

The new advanced multimedia technologies offer special possibilities for an efficient learning and even collaborative learning. Multimedia computers with exciting capabilities have an enormous impact on education; yet the most crucial point is the efficiency and effectiveness of synchronization scheme of multimedia resources.[5]

Multimedia presentation refers to the presentation of collections of both static data (i.e. text or images) and dynamic data (i.e. audio or video). The synchronization model is the determinative factor of specifying when data or events must occur. Therefore multimedia presentation needs to be assured a proper temporal order for synchronizing different educational data.[3][4][5]

2- Distance Learning vs. Face-to-Face

Tallent-Runnels, Thomas, Lan, Cooper, Ahern, Shaw and Liu [Ruth] concluded that learning in an online environment can be as effective as that in traditional classrooms, and students' learning in the online environment is affected by the quality of online instruction. Students in well-designed and well implemented online courses learned significantly more, and more effectively, than those in bad designed and implemented online courses. [4] Figure (1) presents the results of over two hundred different experiments that compared classrooms with various distance learning technologies. Learning, student satisfaction, and course completion data were compared.[4]

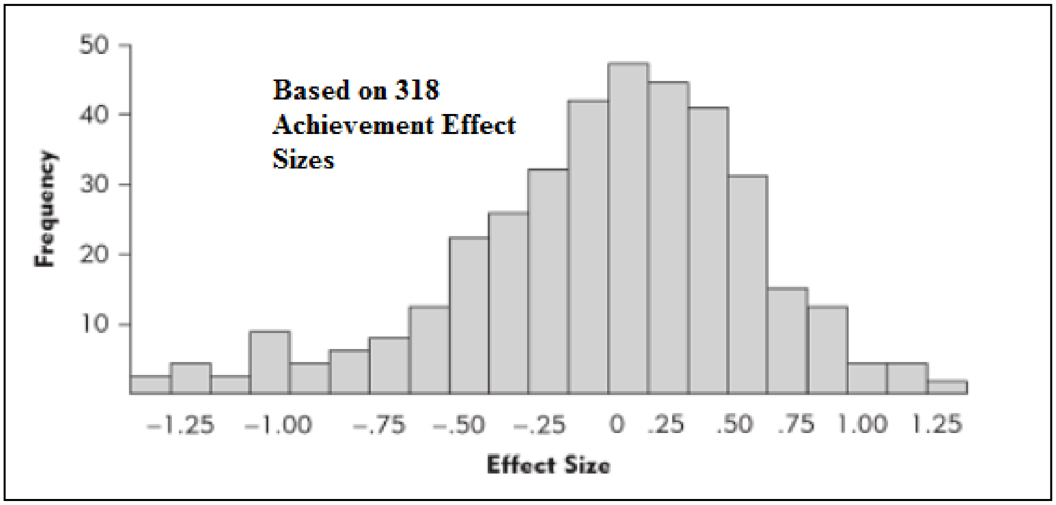

Figure 1: Distance Learning vs. face-to-face show No Practical Differences

3- Synchronous VS. Asynchronous E-Learning [Anita]

Asynchronous e-learning session is conducted when students use material made available through the Web. The time constraints to finish up courses are guided by the students. Web repositories are filled with such courses and figure (2) presents common components of this type to delivery. Asynchronous courses are delivered through CDs, DVDs and Online medium. [4][5][6]

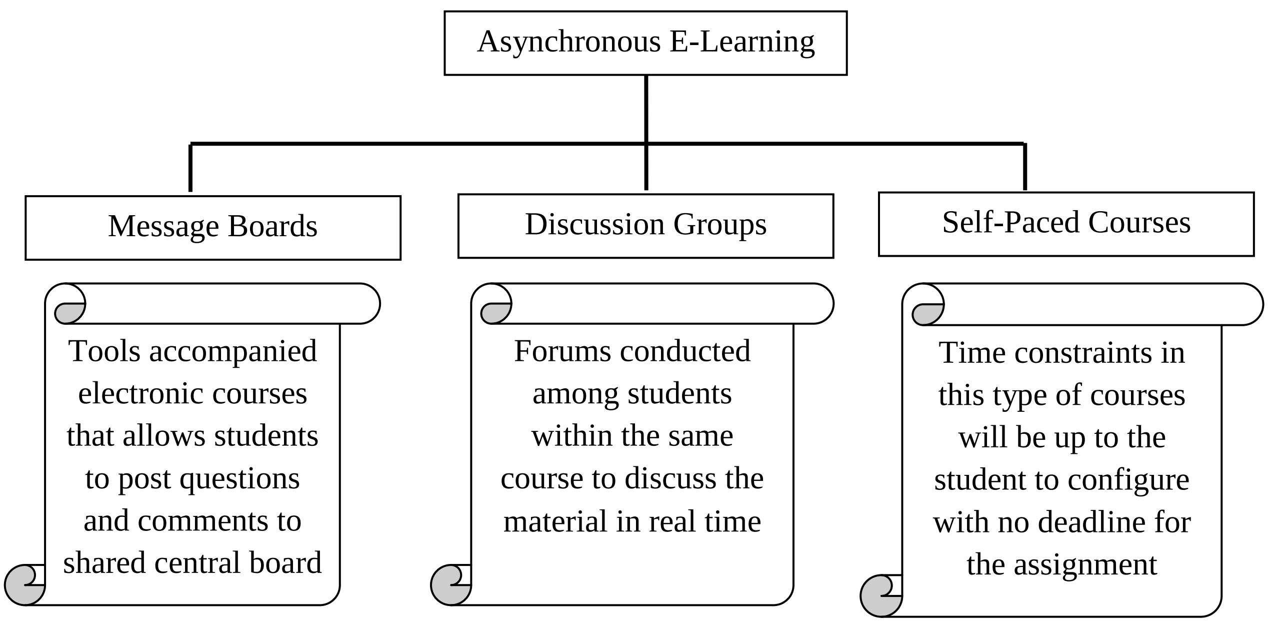

Figure 2 : Asynchronous E-Learning Common Components

Synchronous e-learning session is analogous to traditional classroom training where the instructor and students are together on a conference call, log onto the same Web page, or log onto an on-line whiteboard facility.[2][6] PowerPoint is currently the most popular authoring tool for this kind of session, but it requires a delivery mechanism that converts it into Web-deliverable format. Most synchronous delivery systems include a shared whiteboard for viewing presentation content or for allowing instructor to share their computer's desktop with learners. The instructor controls what is shown, while the students listen to the lecture and view the whiteboard. The instructor can hand control over to a student to make a diagram or a question or to permit the teacher to view the student's desktop. Most communication is done through message boards or instant messaging (IM). The instructor either fixes or entirely controls the content sequence.[6][7] Figure (3) presents the common components of this kind of delivery sessions which are conducted through online (i.e., web or the cloud) or through internal networks (LAN).

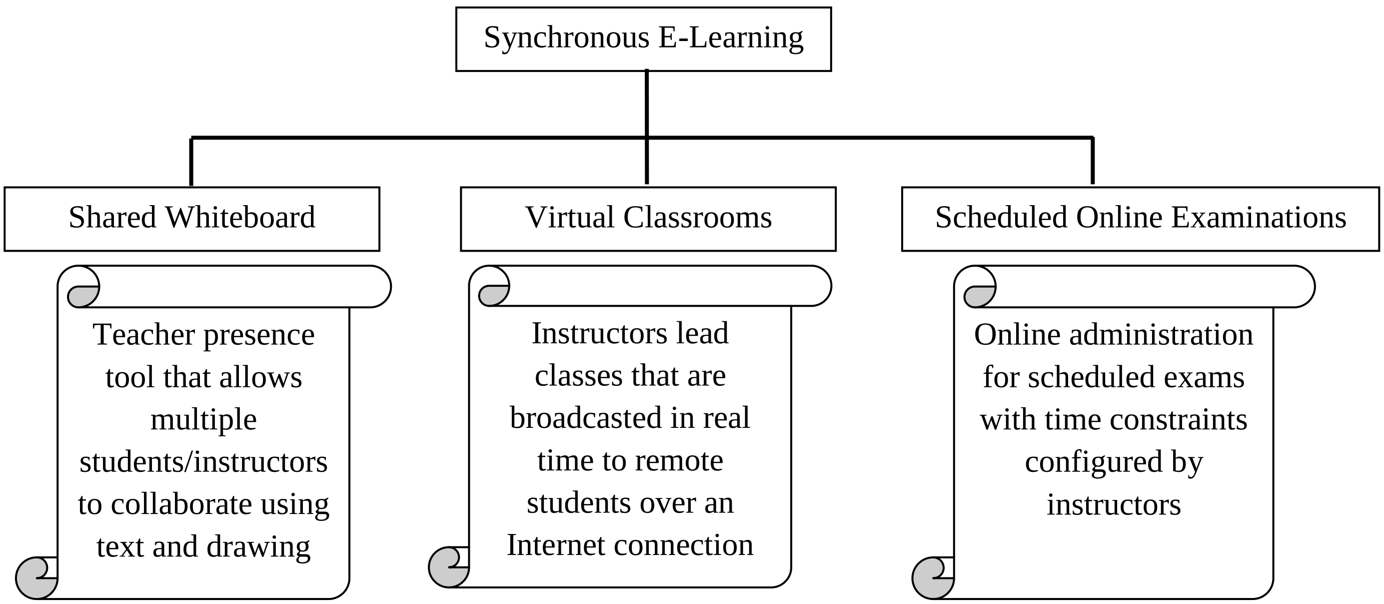

Figure 3 : synchronous E-Learning Common Components

4- Successful Virtual Classroom Features

The most effective features that a successful design for a virtual classroom should consider are presented in figure (4) and it could be summarized as the following: [4]

4-1 Facilities for communication modes (Audio, text, images and other visuals): Most virtual classrooms GUIs offer a capability of interacting between instructor and student in a two-way audio. Audio has proven to be the most effective parameter in delivering information. Speech is a special form of audio that it stimulates student intuitive cognition system. In combining speech with visual materials a huge of perceiving is occurred. Although audio has the great impact on audience for explaining visuals, textual explanation can be very effective especially with powerful potential capability to search that explanation. [1][2][3][6]

4-2 Response options for overt learner engagement: another essential aspect of synchronous virtual classroom is the opportunity for rehearsal, during which the interactivity is sustained through mutual stimulation of information. for answering questions introduced by the instructors or solving simple exercises. Virtual classroom software posses many downloadable modules that can be downloaded at student side and executed. The results are to be sent again to the instructor side.[4][5]

4-3 Instructor-paced delivery of content: instructor determination for the rate of accomplishing the course is a metric of live interactivity between instructor and student.

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Some materials are self paced (i.e., ebooks, tutorials) where the student can finish it up to his time schedule; this is the asynchronous scenario. While other materials require the real time presence of both the instructor and the student; this is the synchronous scenario.[4][5]

4-4 Social learning facilities : students who worked in groups can produce more than they produce individually. This imposes the existence of tools in virtual classrooms to accomplish this collaboration.[4]

Communication Mode	
Rehearsal	
Pacing	
Social Learning Facilities	

Figure 4 : Four Media Features that Influence Learning

5- Narrow band Internet and Virtual Classes challenges

Narrowband Internet is one of the biggest challenges facing the emulating of conventional classroom due to lack of rapid intuitive interaction that is available in the physical face-to-face classrooms. [1] Delay in the responses between lecturers and students, who met over the Internet, is leading to losing subtle sensory cues of gesture, expression, position and voice which is the dramatic case in the narrowband.[1][7] Unfortunately, internet bandwidth pull back the scalability of web application due to the Saturation of internet segments with data traffic. To overcome bandwidth limitation many solutions are introduced:

5-1 Increase the bandwidth subscription for the web application; this yields more cost added to the expenses of implementing virtual classrooms.

5-2 Reduce the back and forth data exchange where the execution of web application could be split into two software modules (i.e., one resides on the web application server and the other on client side). Each module should reduce referencing each other as it is possible for example Cache server can be used to store service code that is frequently requested which leads eventually to reduce the traffic on the backbone network.

5-3 Bandwidth compression and this implies reducing number of data packets sent over the internet in certain time.

6- Problem Statement targeted by this paper

1- Virtual classroom contents (i.e., blackboard, presentation files, images, interactive visual contents, speech) are sent over the internet using non-reliable protocol (HTTP). And classroom contents are streamed with different rates (i.e., each content type has its own coding methodologies such as speech, text and images) that introduce the problem of synchronizing these streams.

2- Narrowband network does not provide enough vacancy to hold all streams of classroom contents at the same time; this demand powerful coding and synchronization schemes to support efficient knowledge delivery in a cognitive teaching session established over narrowband network.
3- Race condition is an occupation of single stream over the network bandwidth and postpone other streams from reaching students' side.

7- Classrooms Synchronization Protocol

E-Learning synchronization models presented in previous efforts focused upon introducing software facilities to accomplish live classroom session; where teacher can interact with students using introduced facilities like shared whiteboard. This paper is introducing another approach to establish real and live classroom session.

Previous models are streaming virtual classroom contents from teacher to students and vice-versa in a fashion that the Race condition is not handled for example voice conference can occupy the available bandwidth and leaving very narrow bandwidth for other streams. Figure (5) presents the protocol stack introduced by this paper.

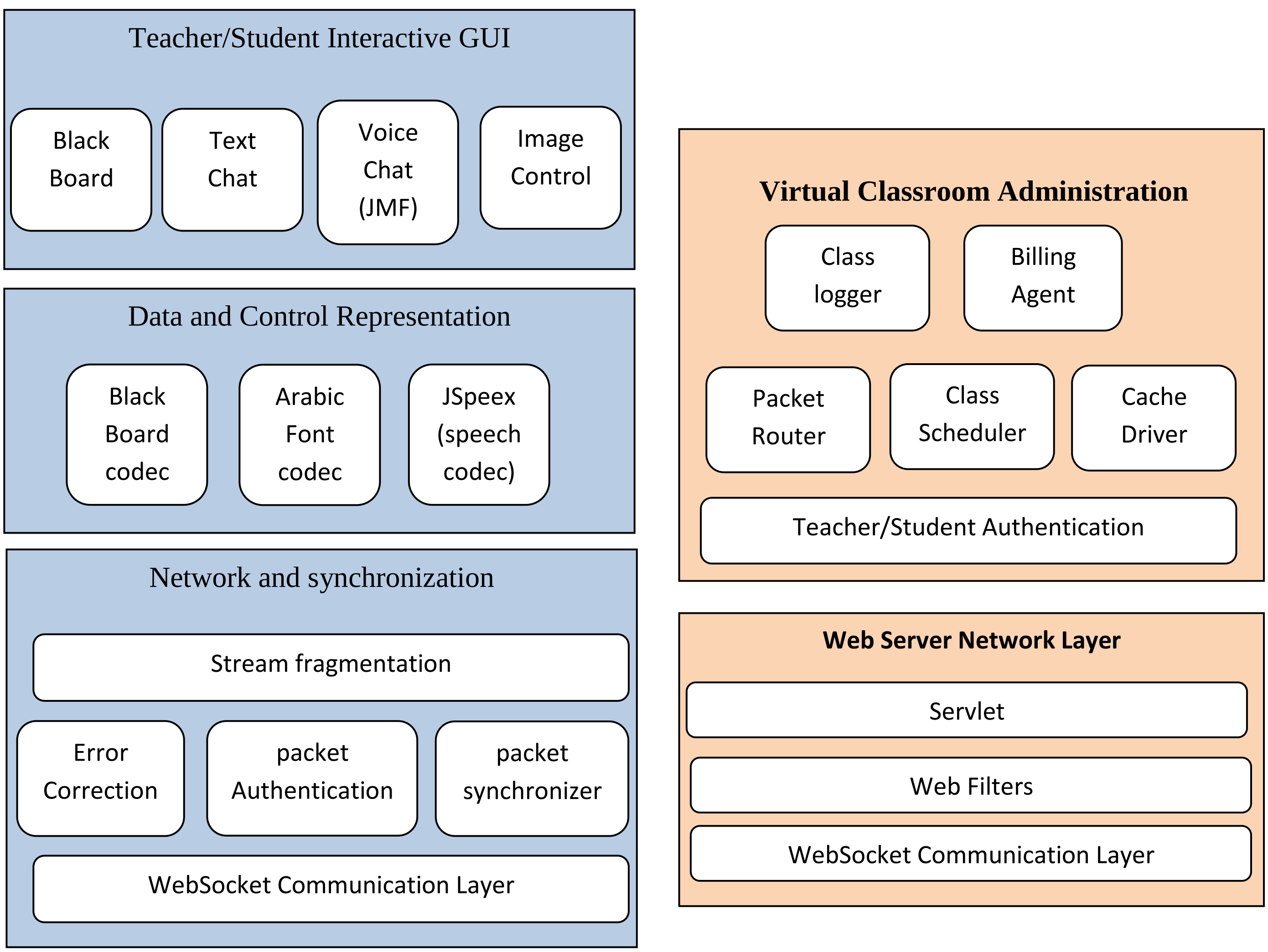


Figure 5: Proposed Server and client side Protocol Stack Architecture

The proposed protocol handled Race Condition Issue through the use of queue system and prioritized round robin scheduling algorithm. Figure (6) presented 10 samples taken over all virtual classroom queues (i.e., each queue is representing a content within the class). The sampling is started with ‘speech and ends with ‘text and keep rounding till exhausting all queues. Sampled queues are represent the first stream to send. As figure (5) presents; a representation layer is exists to manipulate virtual class contents before marshaling it to network layer down the stack. Figure (7) presents a conceptual view of the interaction between protocol layers. It is clear that two types of queues are required: first is the object queue which is a concurrent linked queue (i.e., synchronized queue) and second is the primitive queue that holds byte streams and speech codes.

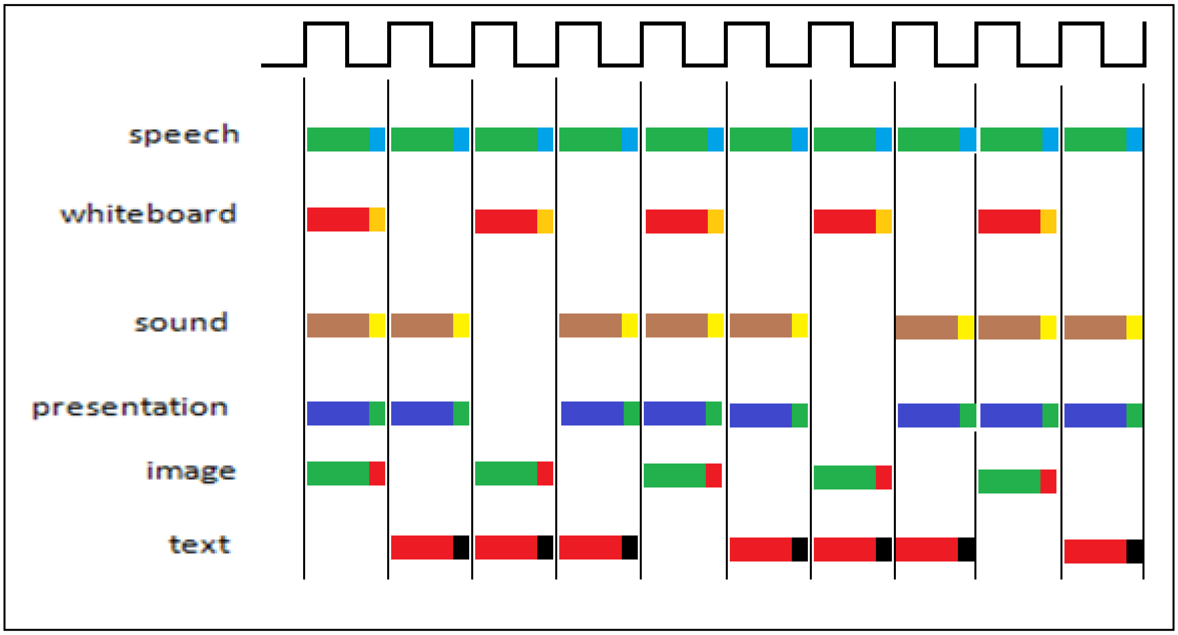


Figure 6 : Sampling Virtual Classroom Queues and Packetizing contents

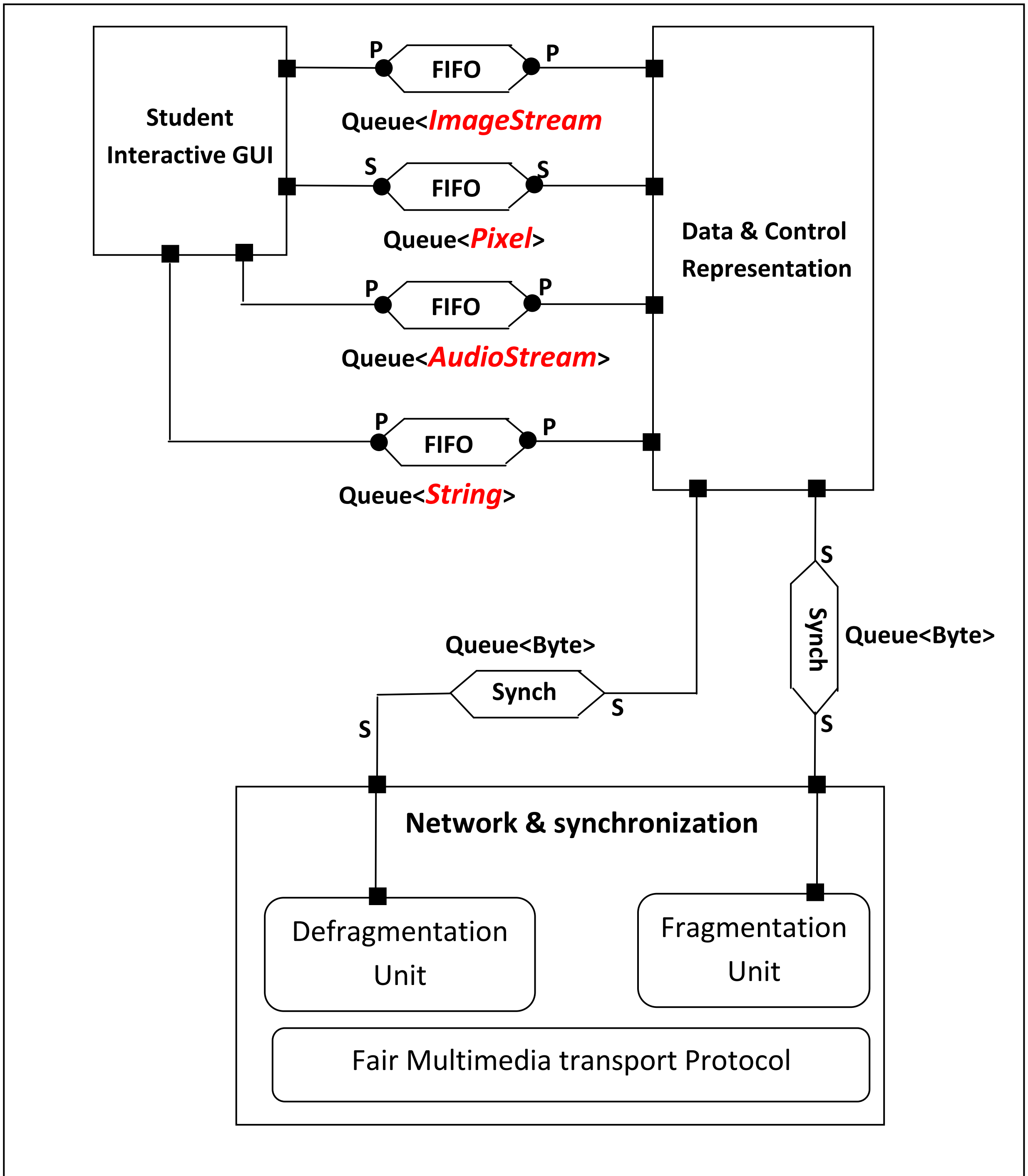
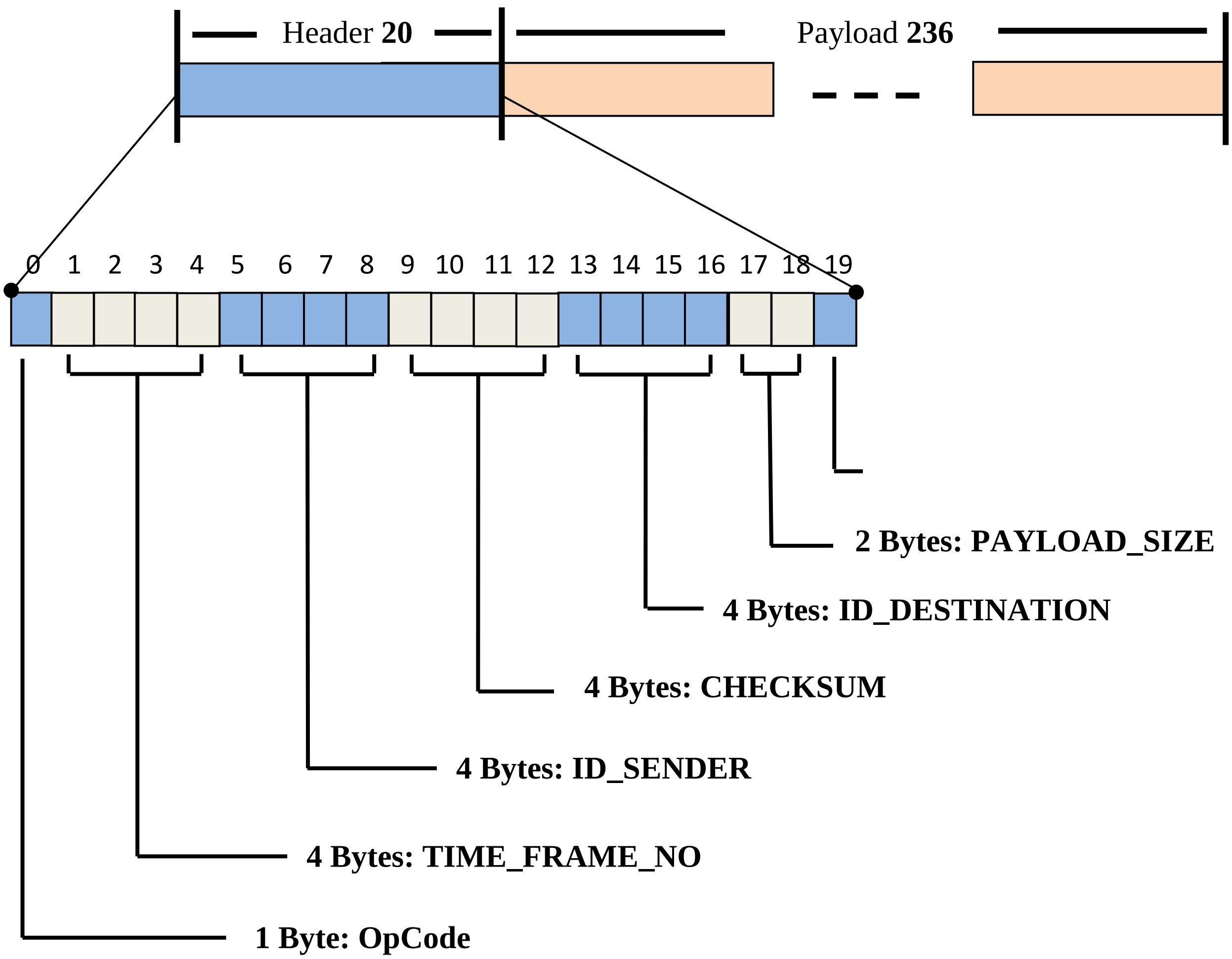


Figure 7 : Conceptual View for Virtual Class Client Side

Figure (8) presents the bitmap layout for the basic packet structure used in the proposed protocol. It is mainly composed of header and payload where the header contains information needed to synchronize this packet within the communication session.



value	opcode
11	Get
12	Set
13	Clear
14	Ack
Ord($)	Unknown

Figure 8 : Whiteboard Packet Structure used by Proposed Protocol

This packet is encapsulated in HTTP envelope and send over the internet to the server side. The payload is holding the contents of the virtual classroom. Each HTTP packet is holding one type (i.e., whiteboard, image, text). The flexible size of HTTP packet (i.e., inherited from TCP/IP flexibility) grants the opportunity to optimize packet size to exactly the contents. Figure (9, 10 and 11) presents the bitmap layout of image, text and speech respectively.

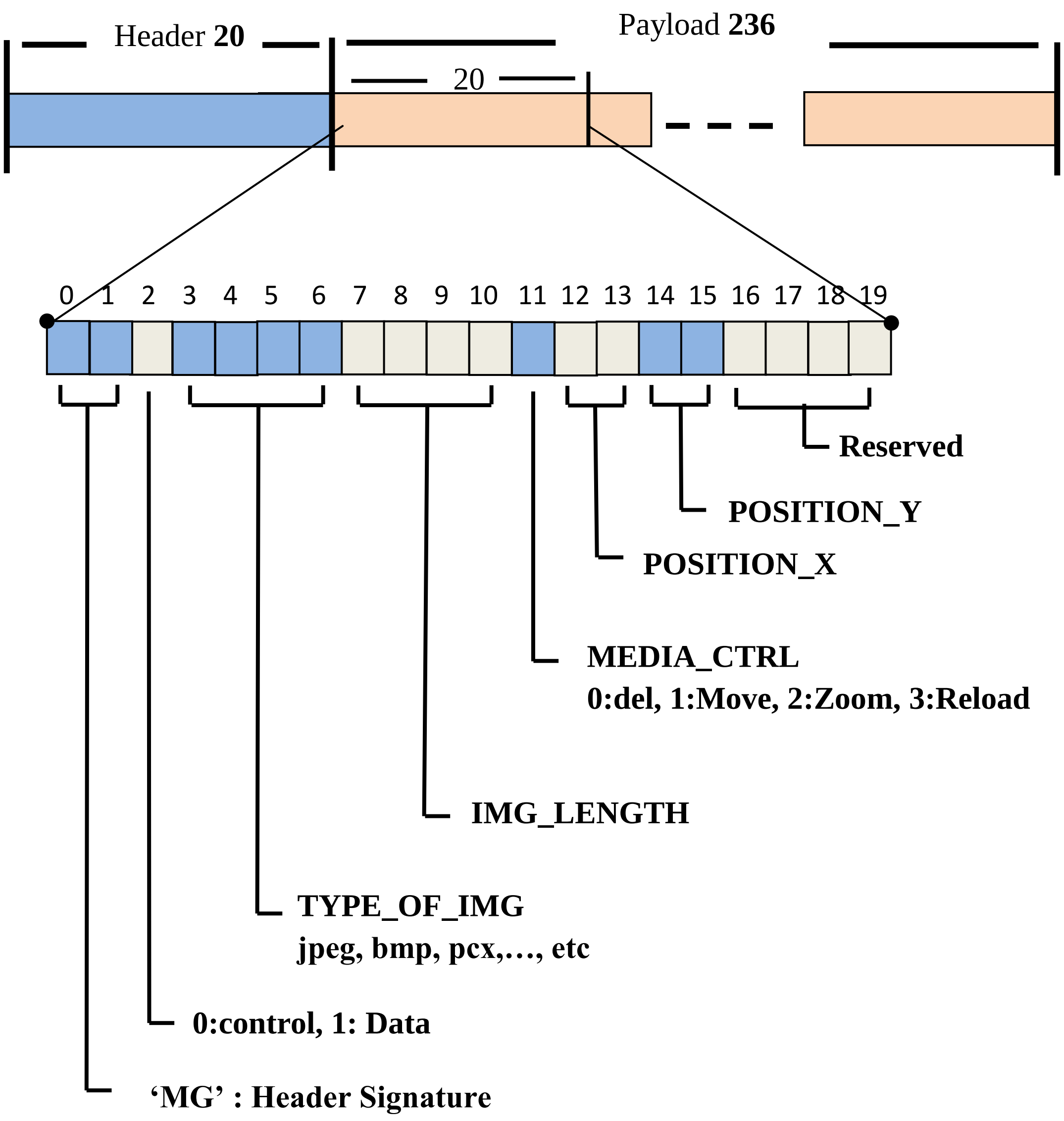


Figure 9 : Image Packet Structure used by Proposed Protocol

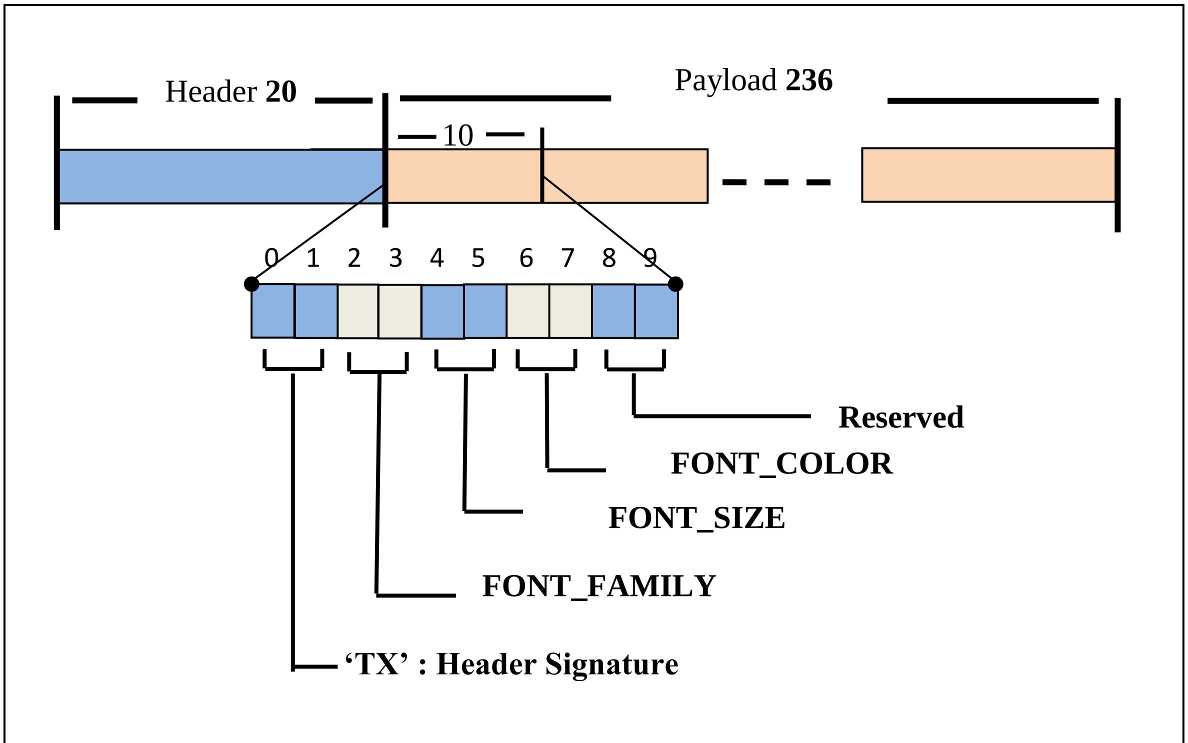


Figure 10 : Text Packet Structure used by Proposed Protocol

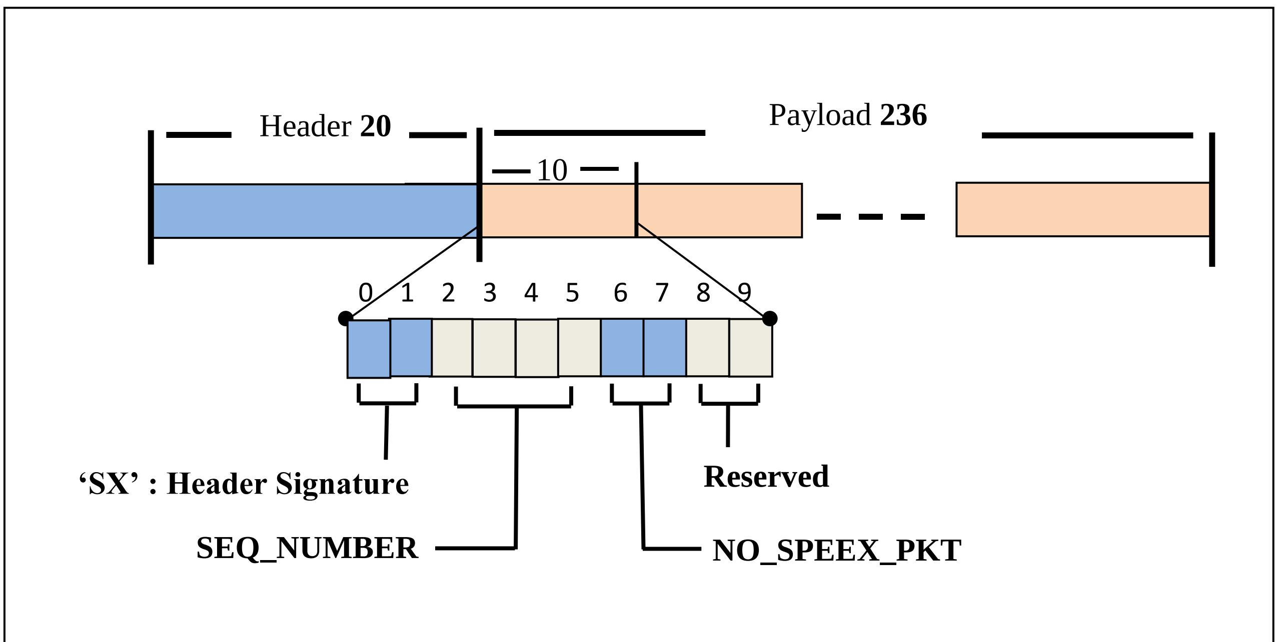


Figure 11 : Speech Packet Structure used by Proposed Protocol

The most crucial interaction factors are speech and whiteboard; where students are normally grant their attention to what is written on the whiteboard as it synchronized with instructor's speech. Table 1 and 2 represents data collected through an experiment along the implementation of this proposal

Time / sec	Size / kbytes	JSpeex packet/ Kbytes
1	45	2.4
2	167	11
4	331	19.2
6	385	22
8	447	25.3
10	583	37.8

Table 1: instructor's speech coded using JSpeex classes

Time / sec	Size / kbytes	White board codec/ Kbytes
1	0.5	0.1
2	1.2	0.2
4	1.8	0.31
6	2.3	0.4
8	3.5	0.7
10	5	1

Table 2: instructor's writing on whiteboard

The experiment has conducted with CDMA modem with a bandwidth of 10 – 12 kbps and the session has proven to be realistic and synchronized. The same experiment has been repeated with skype version 5.5.0.124 and the students lost focus due to race condition raised by the skype in monopolizing the available bandwidth.

8- Conclusions

1- Synchronizing virtual classroom session over the internet is not guaranteed by only expanding the network bandwidth due to the monopolizing of one multimedia stream over that bandwidth, in other words, race condition is depriving late accumulated contents from being transmitted over the internet if other content is saturated the bandwidth.

2- Broadcasting virtual class contents according to fair play algorithm does not solve the problem of establishing the synchronization due to different compression rates for different types of media (i.e., speech could be compressed more than normal sounds). This will end up losing the synchronization between the contents.

3- Distributed scheme can be deployed to utilize bandwidth. Virtual classroom can be published we web service over a cloud environment. Students can join the same classroom but over a distributed servers. This will indeed reduce the traffic over certain network segments and provides many alternative paths to the classroom.

9- References

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