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Broadcasting Scheme for Wireless Network in an Educational Organization

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Abstract: Video on Demand in an educational organization can help students (learners) to go through their lectures either first time (if they have skipped) or again if they have not followed. With the advent of broadband networking technologies and the growth in processor speed, disk capacity, also the development of high efficiency video and audio standards and ever increasing hand held devices we tried to focus on providing the VOD solution for wireless networks in an Educational Organization.

Keywords: Video on Demand, Broadcasting Schemes, Harmonic, Fibonacci term based broadcasting, Wireless, Educational Organization

I. Introduction

Application architecture i.e. design for current VoD system used in modern network applications can be of Client Server architecture, Peer to Peer architecture, and periodic broadcast. In Video on Demand system a student can watch the video of lecture at the time of his / her choice.

In the Client Server Architecture there is always on host, called the server, which services request from many other hosts, called clients. The issue with the Client server architecture is the scalability. In any Video on Demand two issues has been highlighted by many researchers namely Client I/O Bandwidth and Storage Requirement.

P2P network is another architecture that can support the distribution of content. It is compelling content distribution paradigm as all content is transferred directly between ordinary peers without passing through third party servers. InP2P there are 3 architectures that are available for locating contents namely Centralized directory, Fully Distributed approach and Hybrid Approach

II. Overview of the Periodic broadcasting protocols

The basic of periodic broadcasting schemes is to divide the video into series of segments and broadcast each segment periodically on dedicated server channels. So the aim is to divide the video in such a way to achieve the lowest server bandwidth and also guarantee on time delivery of each segment. Simplest broadcasting protocol is the staggered broadcasting protocol [1]. In this protocol client access latency could not be improved unless there is increase in corresponding server bandwidth.

Other efficient broadcasting protocols can be subdivided as

- i) That partitions the video into increasing size of segments and transmits them in logical channels of same bandwidth.
- ii) That partitions the video into equal size segment and transmits them in logical channels of decreasing bandwidth
- iii) The hybrid of the above two.

Pyramid Broadcasting protocols[2] are based on first subdivision, that partitions the video into increasing size of segments and transmits them in logical channels of same bandwidth. In this protocol each segment has to be transmitted at a very high rate and client I/O bandwidth and storage requirements are also high.

To remove this drawback of high transmission rate, high client I/O and high storage requirements a Permutation based pyramid broadcasting protocol [3] and Skyscraper Broadcasting protocol [4] was proposed. To further improve the server bandwidth performance Fast Broadcasting protocol [5] was proposed

Harmonic broadcasting [6] used the second approach i.e. which partitions the video into equal size segment and transmits them in logical channels of decreasing bandwidth. This requires much less server bandwidth than that the Pyramid based, Permutation based pyramid, skyscraper and fast broadcasting protocols however it has been found that it cannot deliver all the data on time. To solve this problem Cautious Harmonic broadcasting, Quasi Harmonic broadcasting protocols and Poly-harmonic protocols [7,8] were proposed. However to further reduce the server bandwidth in, Harmonic, Cautious Harmonic broadcasting; Quasi Harmonic broadcasting protocols and Poly-harmonic protocols requires more logical channels

Pagoda Protocols which is basically hybrid of Pyramid and Harmonic based protocols. They partition the video into fixed size segments and map them into smaller number of data streams of equal bandwidth and use time division multiplexing to ensure successive segments of a given video are broadcast at the proper decreasing frequencies thus significantly reducing bandwidth requirement and at the same time do not uses more logical streams.

III. Fibonacci based Broadcasting scheme

We use S to denote the total length(in time units) of the video, S_i the i^{th} segment, w the client waiting time requirement, b the video consumption or display rate and the n the number of segments for a given video. We will use the same principle as employed by Harmonic broadcasting Scheme [6] i.e. partitions the video into equal size segment and transmits them in logical channels of decreasing bandwidth. Size of the movie $S = D \cdot b$ where D is the movie with length D and b is the consumption rate. To reduce the viewers waiting time, d , we divide movie into N segments where N is a positive integer.

Policy for Divisions of Segments

Whole movie will constitutes the following segments and whole movie is concatenation of segment numbers in the increasing order $S_1, S_2, S_3, S_4, S_5, \dots, S_N$.

The i^{th} segment of the movie S_i (for $i > 2$) is divided into sub-segments(s) as per the Fibonacci terms however, segment 1 and Segment 2 will not be divided as the seed value of $F_1 = 1$ and $F_2 = 1$

$$S_1 = 1$$

$$S_2 = 1$$

From the segment 3 onwards the division of segment will be as per the rule

$$X_n = X_{n-1} + X_{n-2} \text{ Where } X_n \text{ is } n^{\text{th}} \text{ term of Fibonacci series}$$

So the segment S_3 is divided into 2 segments S_{31} and S_{32} and segment S_4 is divided into 3 segments S_{41} , S_{42} and S_{43} and so on.

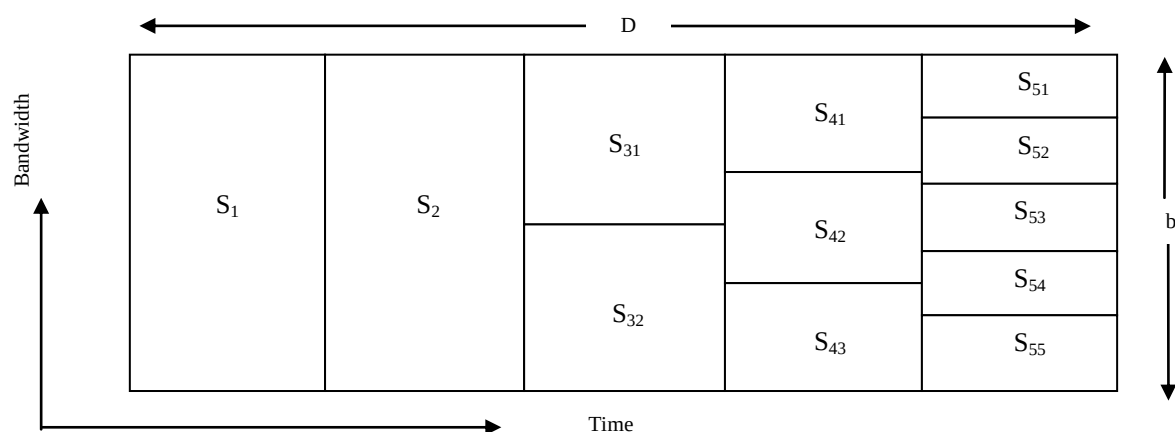


Figure 1: Policy for division of Segments

Policy for Allocation of Segments to Logical Channels

Let the i^{th} sub-segments of S_i be put on the logical channel C_i . Thus logical channel C_1 will be having segment S_1 , C_2 will be having S_2 , C_3 will be having S_{31} , S_{32} , and C_4 will be having S_{41} , S_{42} and S_{43} and so on.

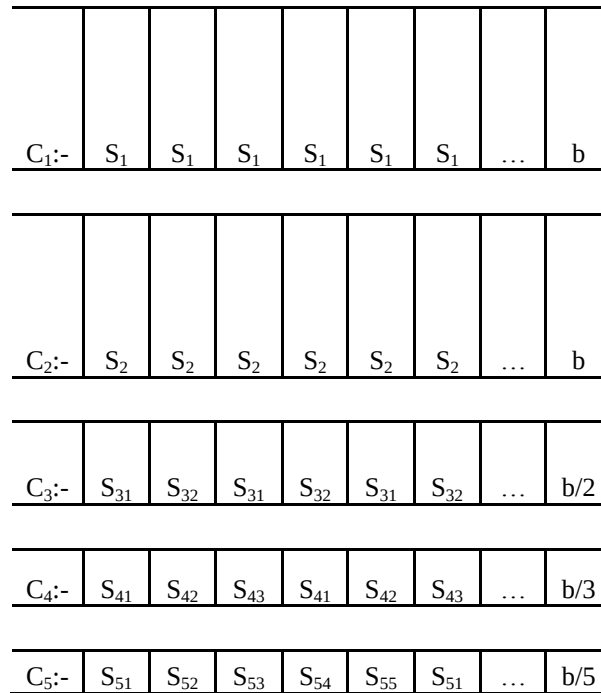


Figure 2: Policy for Allocation of logic channels

Bandwidth of C_1 and C_2 is b , C_3 is $b/2$, C_4 is $b/3$ and C_5 is $b/5$ and so on. Within C_i , the i^{th} sub-segments of S_i are broadcasted as shown in figure 2. Hence, the total bandwidth for the movie is

$$B = b \text{ for } N=1$$

$$B = b + b = 2b \text{ for } N=2$$

$$B = 2b + b/2 = 5b/2 \text{ for } N=3$$

$$B = 5b/2 + b/3 = 17b/6 \text{ for } N=4$$

$$B = 17b/6 + b/8 = 142b/48 \text{ for } N=5$$

$$B = 142b/48 + b/13 \text{ for } N=6$$

$$B = \text{Fib}_N \cdot b$$

$$\text{Fib}_N = \sum_{i=3}^N \frac{1}{X_i}$$

Where $X_i = i^{\text{th}}$ Term of Fibonacci sequence and X_1 and X_2 being 1 and Fib_N is Fibonacci term.

Assuming we have enough buffers to keep the data segments of movie. For watching a movie

Download the first segment S_1 of the required movie at the first occurrence on C_1 and other related data segments from $C_2, \dots, C_N$ simultaneously

As soon data segments are downloaded we can start outputting the movie in order of $S_1 S_2 \dots S_N$. When i^{th} sub segment of S_i is downloaded stop loading from $C_i = (1, \dots, N)$. The previously downloaded $i-1$ sub-segments(s) of S_i will be written to local buffer first however they will be consumed with the last received sub-segments of S_i concurrently.

IV. Relationship between waiting time and network bandwidth allocation

From the above Fibonacci based broadcasting scheme it can be seen in figure 3 that we do not require to allocate 4 video channels for a movie. Suppose the length of a MPEG 4 movie is 60 minutes. The waiting time will be $60/20 = 3$ minutes. For a lecture to be of 1 hour the student waiting time can be reduced to less than 1 minutes by selecting 4 video channels.

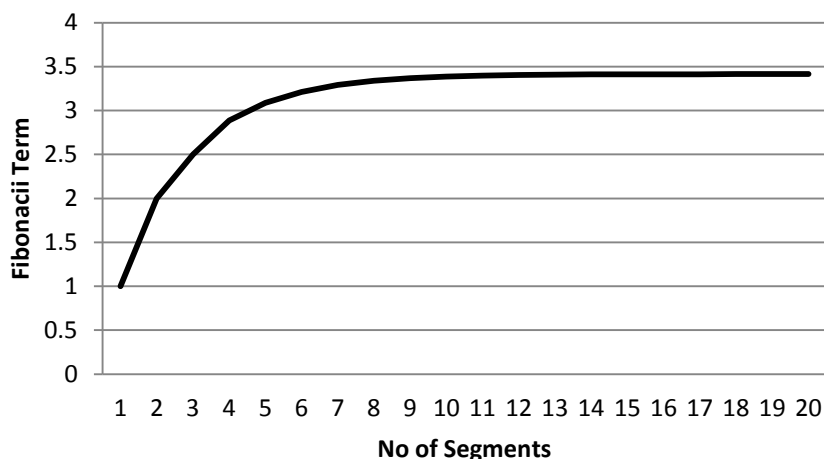


Figure 3 Fibonacci based Broadcasting Scheme

From the above relations it can be seen that $Fib_N < 3.5$ as N increases, where N is the number of segments. For the safer side if we assume $Fib_N = 3$ video channels to broadcast a video we have $N = 20$. Suppose the length of a MPEG 4 movie is 60 minutes. The waiting time will be $60/15 = 4$ minutes. For a lecture to be of 1 hour the student waiting time can be reduced to less than 1 minutes by selecting 3 video channels.

V. Storage Requirements at Client End

Arriving rate of the movie will always be greater than the consumption rate when $N > 1$. Thus it is desirable to buffer portions of the playing video on the disk.

The storage (buffer size) requirement of this scheme will be bit more than harmonic based scheme as segment S1 and S2 are being broadcasted at the bandwidth b . However now client comes with sufficient buffer this should not be a concern.

VI. Architecture of Proposed VOD System for Wireless Networks

As there has been lot of advancement of broadband networking technologies and the growth in processor speed and disk capacity, also the development of high efficiency video and audio standards encoded by MPEG-2[9] and MPEG-4[10] is being used as the format of digital television signals that are broadcast over the air, cable and direct satellite TV Systems the Video on demand system has become possible. The use of MPEG-4 includes compression of audio and visual digital data for web and CD distribution, voice (telephone, videophone) and broadcast television applications.

In an educational organization, the pre recorded stream of files would be used to present missed class lectures. These streams would be broadcast online. The students who had missed the lectures or those who want to review, can use this scheme by using their computer or hand held devices

In Wireless technologies, standards exists for PAN (IEEE 802.15.3), LAN(802.11), MAN(802.11, 802.16, 802.20) and WAN (GSM, CDMA, Satellite). We will propose a solution for Wireless LAN and in particular infrastructure wireless LANs, with the infrastructure being the Access Points (APs) along with the wired Ethernet infrastructure that interconnects the Access Points and router.

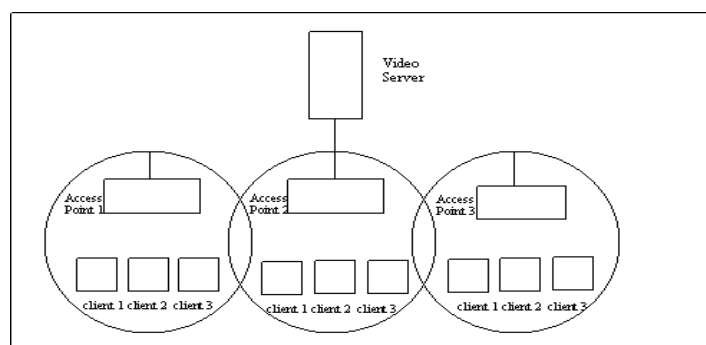


Figure 4: General Architecture of Wireless Network

Based on the general architecture of wireless network system, it can be easily identified that the main component of Video on Demand for wireless system is Video Server which is shown in figure 4. Video server is at core of the system. Since this a client server architecture it is fairly easy to implement however bandwidth usage increases linearly with the number of clients, so do the resources of video server (e.g. the disk capability and transfer rate)

Number of clients accessing the server simultaneously can burden the server. To match up the increasing number of clients, distributed architecture is one of the solutions as shown in figure 5.

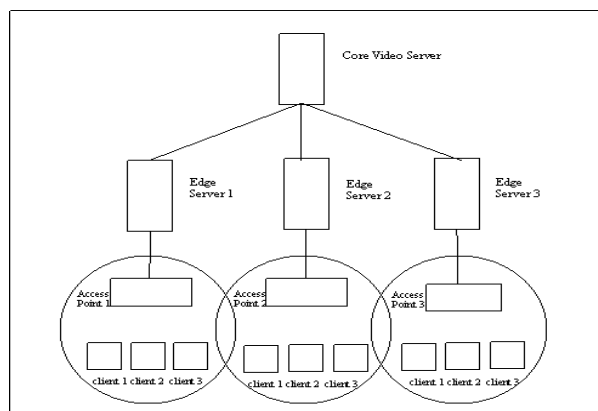


Figure 5: Edge Servers

Video data are saved in core video server, at the same time; some copies are stored in edge servers. When the client requests for the video, the edge server tries to honor the request of client through the access points. If the requested video is not located at edge server, the core server will deliver this video to the edge server via core network. There can be a natural issue of mobility among the Basic Service Set (BSS).

Two possible scenario can exists: **If a interconnection is a hub:** If a wireless client move from its Basic service set (BSS) to another BSS in the same subnet wireless client detects a weakening signal from Access Point 1 and starts to scan a stronger signal. It receives beacons frames form Access Point 2. Wireless client then disassociates from Access Point 1 and associates with Access Point 2 while maintaining its ongoing session.

If interconnection is a switch: If a wireless client move from one basic service set to another, since switches are self learning and before they move, the switch has an entry in a forwarding table that pairs host1 MAC address and the outgoing switch interface through which host1 can be reached. If host1 is in BSS1, then the datagram destined for host1 will be directed via Access point 1, once host1 associates with BSS2, its frame should be directed to Access Point 2. Access point 2 send a broadcast frame with Host 1 source address to the switch just after new association. When switch receives the frame, it updates its forwarding table, allowing Host1 to be reached via Access Point 2.

VII. Conclusions

Architecture of Proposed VoD for an educational organization using wireless network is proposed using the Fibonacci based broadcasting scheme. For a lecture to be of 1 hour, MPEG -4 encoded, the student waiting time can be reduced to less than 1 minutes by selecting 3 video channels using Fibonacci based broadcasting scheme. To reduce the burden of Core servers, load sharing through Edge Servers is also proposed as the bandwidth requirement can be reduced considerably.

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