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StreaMER: Streaming Media Edge Router, A Centralized Multimedia Transcoding Gateway for Multi-bit-rate Networks

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ABSTRACT

This paper proposes a solution for real-time multimedia content management and transcoding as per the requirements of the end user devices. The solution is a self contained streaming media proxy that acts as a gateway for LAN devices to grab requests for multimedia contents from the internet. The solution called "StreaMER, for Streaming Media Edge Router", utilizes a proprietary queuing and scheduling scheme to serve multimedia contents efficiently while minimizing the load on the internet link keeping the quality and flow of steams for LAN users to meet the QoS requirements. StreaMER also acts as a local archive for frequently demanded contents. It serves previously requested contents from its local cache instead of fetching them from the internet, thus reducing the load on the internet link. StreaMER intelligently adjusts the pre-start delay, input/output buffer sizes and resultant video format for the requested streams on the basis of the rate of incoming live stream from the internet and the rate at which LAN user device can show the resultant contents.
KEYWORDS: Multimedia, Stream, Proxy, Transcoding, Multi-bit-rate, GIF conversion

INTRODUCTION

In this era of Information Technology multimedia has taken place of text, text was time taking to read and understand while the same story can be grasp by a single visual scene. As they say that, a picture is worth a thousand words.

In these days in corporate organizations and especially in universities, hundreds of users access internet as a source of information. Most of the information is delivered in the form of Multimedia contents. Although the available bandwidth is limited and the demand for Multimedia Content is increasing. The network administrators are often faced by the challenge of efficient distribution of bandwidth among the growing users.

The recent study by [1] shows that the data traffic for mobile users increasing as goes more than double each year from 2009 till 2014. Figure 1 defines the graph showing the video traffic for 66% of the total of mobile users data and the mobile users expect QoS experience with high quality multimedia in terms of video and voice quality. Researchers and media business holders need to meet the users expectations with the help of network service providers and technology developers to produce affordable and modern technologies are required to achieve the mobile users expectations using wireless multi-technology networks.

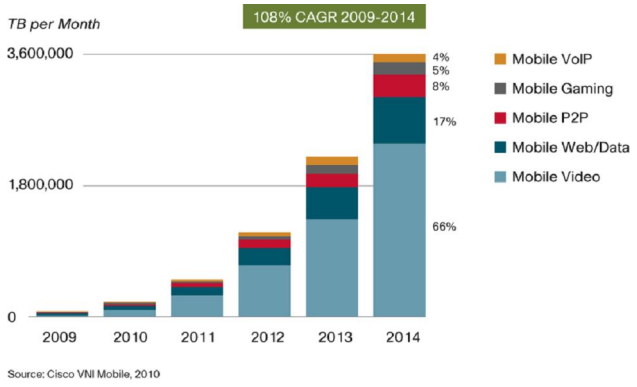

Figure 1: Video Will Account for 66 Percent of Global Mobile

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It is quite common that the LAN bandwidth is about 10 to 100 times greater than the internet bandwidth. Moreover the cost of increasing the internet bandwidth comparative to LAN bandwidth is much higher. Furthermore the availability of internet bandwidth is also depends upon the internet service provider which is usually beyond the control of the end users. If a software product is developed that provides functionality of Re-broadcast of the multimedia contents over the LAN without burdening the internet bandwidth it would be a very cost-effective and scalable solution.

[2] Video on demand means the clients expect for guaranteed continuous video delivery by using resources of network and server in appropriate manner which results a challenge for that video server to deliver multiple video streams as many clients can requests for the same video serving the single input and output stream this scenario of multicasting, blocks of same data set to multiple users. This target can be achieved by making batches for the same video for same requests in small interval of time. In hypertext transfer protocol (http) streaming refers to the continuous delivery of multimedia content like audio or video via http, which supports the client end to consume that media without downloading the entire data on its end-user device.

Media distribution causes the de-facto standard. The two main reasons for this de-facto standard are the equitable connectivity of internet like the bandwidth used for the content and the connectivity is available on anytime anywhere basis and playable on variety of devices. The other reason is that the issues of firewall are not caused by the use of http as faced by using other protocols of media transmission like Real-time Transport Protocol (RTP) or Real Time Streaming Protocol (RTSP) [3].

The main requirements for streaming MPEG media using hypertext transfer protocol can be bunched in following areas; [4]

- Applications and video content like ultra-high definition (UHD) content emergence
- Multi-technology networks and end user device content adaptation capabilities
- Increase in downloads peer to peer and multi-channel delivery of media content
- Merging the content/ data providing services in terms of network
- Security in terms of content protection and administration rights

We propose “Streaming Media Edge Router (StreaMER)” system that will serve as a transparent multimedia proxy server that provides transcoding of multimedia contents between internet server and the LAN users. The StreaMER will capture all LAN requests for multimedia contents and queue them locally. If multiple users are requesting the same contents, the StreaMER will only create a single entry in its queue, thus reducing the demand on the internet bandwidth. Alternatively the network administrators will be able to schedule multimedia content download by analyzing the statistics of commonly requested contents. StreaMER will also provide the functionality of real time conversion of live streaming contents from the internet servers into appropriate formats as required by the end user video clients. This feature is also helpful in case the end user device has hardware limitations such as screen size, CPU, memory, storage and connectivity as in case of PDAs and Smart Phones. For scheduled media and accessed contents StreaMER will allow local storage of contents for later delivery on demand. StreaMER downloads the internet contents independent of its LAN usage.

As the video streaming quality can be pointedly improved by using appropriate and suitable buffering while an undesirable delay in performance can be a result of too much buffering. To handle the performance delays particularly on peer to peer networks the measurement platforms are used to get perceptions in peers regarding the delays in startup, intervals of time when a channel is active to the actual play-back starts, and play-back pauses. Startup buffering has been a valuable technique dealing appropriately with rate variations in multimedia content streaming sessions [5].

When a user first demands any multimedia content StreaMER notifies the user with a locally played audio message indicating that the requested content will be available shortly. During this time StreaMER estimates the minimum time required to buffer sufficient contents in such a way that a balance is maintained between the download from the internet and the play back over the LAN. StreaMER utilizes a Dynamic Dual Buffer Technology TM (D2BT) to compensate for the internet performance degradation without affecting the performance of the end users contents. A second audio message will notify the approximate delay after which the desired contents will be delivered to the user. By locally storing the internet content StreaMER will provide the archival of long term contents for later use. This also provides the flexible features such as time shifting of multimedia contents for the end user.

HTTP media streaming targets to achieve the main objectives [6];

- Moving Picture Experts Group (MPEG) media competent delivery of http stream in terms of adaptation and provisioning of content.
- Live streaming support of multi-media content.
- Proficient use of multi technology networks with components like proxy, cache and firewall etc. providing the combined services to the end user.
- Delivering the secure administration and data forwarding and rely.

Mainly three functional domains are defining the scope [7];

- Encapsulation: format of data stored on storage device or delivered as payload via http as a target protocol.
- Content Delivery: using the target hypertext transfer protocol.
- Features like maintaining sessions, service discovery and management are handled by the interactive protocol.

Media streaming requirements are categorized as; the content/ data, delivery, display/ presentation, content adaptation, data security.

IMPLEMENTATION

StreaMER is based on Open source components that provide all the features available in this software. Figure 2 shows the components integrated in StreaMER for its deployment on Local Area Network (LAN).

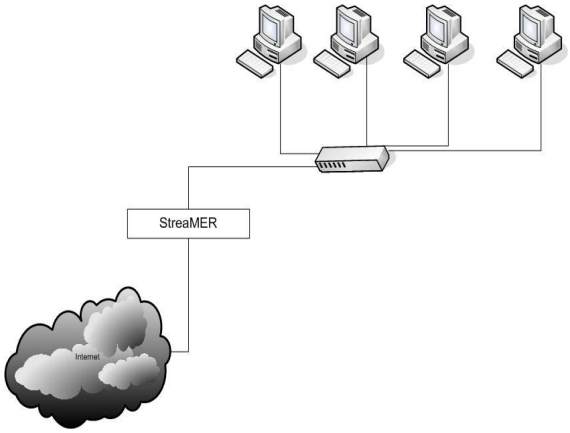

Figure 2: StreaMER, Local Area Network Deployment

Figure 3 defines the StreaMER internal architecture as follows;

1. Hardware

- 3.0 Ghz Dual Xeon processor system
- 2 GB RAM
- 160 GB hard drive for storage
- 2 network cards in bridge mode

2. Software

- Squid Proxy
- IP Chains/ IP Tables
- Snort IPS
- Multimedia buffering and streaming framework
- Apache Web server

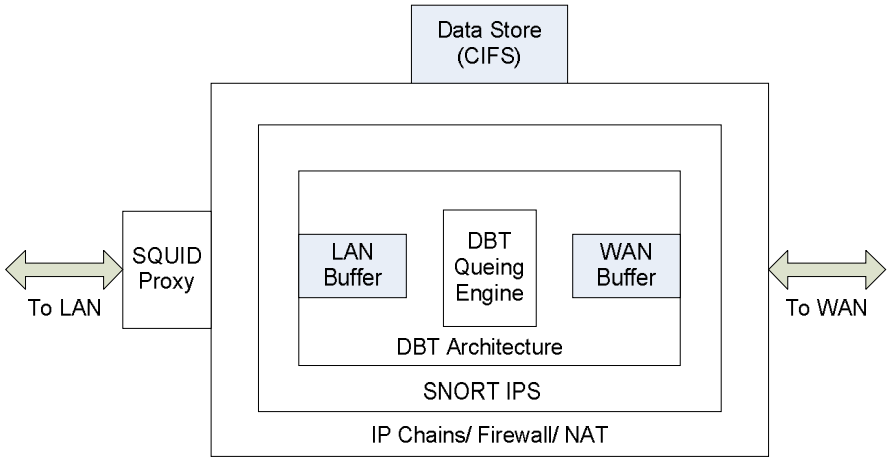

Figure 3: StreaMER Internal Architecture

2.1. SQUID Proxy server

SQUID proxy server will function as a web proxy for fetching the http and https streams from the internet as most of the streaming contents are streamed using HTTP protocol these days. It forwards the contents to the DBT architecture for further processing. SQUID also acts as a transparent web proxy for Multimedia Stream Grabbing.

2.2. IP Chains/IP Tables Firewall/ NAT

This component will provide NAT features for the LAN users and utilizes services of Dynamic Dual Buffer Technology (D2BT) for efficient content delivery to the StreaMER clients.

2.3. Snort IPS

Snort provides detection or blocking of any type of contents and its forwarding to the D2BT architecture. Thus providing total control over the contents passing though StreaMER.

2.4. Dual Buffer Technology Architecture

StreaMER utilizes unique multimedia stream buffering architecture that intelligently tunes its buffer sizes, queuing strategies and Stream profile adjustment on the fly to accommodate transcoding of any type of multimedia contents being received from the internet.

2.5. Apache Web server

Apache web server provides flexible user interface and catalog of multimedia contents being played or stored on the StreaMER.

3. *Streaming Media Framework (Transcoder) Queuing Engine*

The StreaMER requires expertise in the following areas:

1. Network programming
2. Operating systems API Programming
3. Streaming Concepts
4. Queuing concepts
5. Media format transcoding concepts

Although StreaMER can be used in any environment, we particularly focus on its educational use where the number of computers available is quite high compared to an average business. An average university with 5 departments with 4 computer labs in each department (each lab with 40 computers with 384 Kbps bandwidth requirement per PC) will require a combined bandwidth of storage of 5 x 4 x 40 x 64 = 51.200 Mbps at min. StreaMER will serve the same number of PCs within the available bandwidth by efficient queuing, buffering and

local storage. Although StreaMER can be implemented on any Operating System platform, but due to the stability, reliability and cost effectiveness of open source UNIX variant operating systems we planned to implement StreaMER on Fedora.

Figure 4 defines the interactivity of media player with media streaming engine when buffered a particular amount of adjacent chunks of content attending by the media player which then makes a request for http to the streaming engine. On these requests the streaming engine does reply back by sending video to the media player. The buffering on receiving video is done by media player which begins to render the video data when the sufficient amount of video data has buffered. The media player will be famished if the streaming engine unable to supply the video data at a sufficient rate to media player. When this state occurs the streaming engine may have the media player wait where it left off or skip the frames depending on the severity of starvation at media player [8].

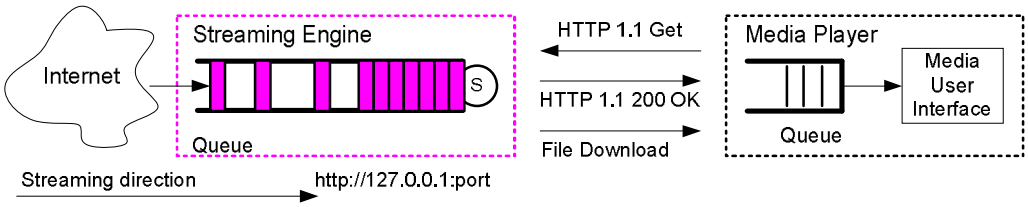

Figure 4: Streaming process systems

Any User who wants to Access Multimedia Contents from the internet may use any standard web browser such as internet explorer (version 6 or later), Firefox, Mozila or Opera. Similarly any standard multimedia client software such as Windows Media Player, VLC, Jet Audio, Winamp for PCs or Realplayer, Smart Movie, Pocket TV or CorePlayer for PDAs and Smart phones. Depending upon the availability of codec and Hardware profile of the client device the StreaMER will trans-code the contents in the appropriate format.

4. Video to GIF Conversion Module

GIF The Graphics Interchange Format is a bitmap image first introduced by CompuServe in 1987 [9] and by the time GIF became the active part of World Wide Web due to its wider support and portability. The GIF format supports up to 8 bits per pixel for each single image which gives each single image to refer its palette up to 256 colors from 24 bit Red Green Blue (RGB) color space. StreaMER uses GIF quality of color as well as its support of animations with up to 256 colors for each frame and GIF another quality of compression to reduce the file size without compromising the visual quality.

[10] Presents an addition of image converter between the personal computer's image memory and video controller several functions can be accomplished without rise of load on PC's CPU. These real time functionalities may be mirroring, inverting or rotating on image. Mentioned converter works to store data in terms of picture's chrominance and luminance by using a video RAM and a first bus transmitter, transmitting synchronized image data by remaining connected with image memory and video controller.

The video to animated GIF conversion module, shown in Figure 5, works in the sequence that the main engine picks the movie frames and converts these frames to animated GIF and then these GIF images are played at end user devices without the support of any video player. Beside this the animated GIFs are then removed from the memory after play providing the low memory usage functionality at end user device.

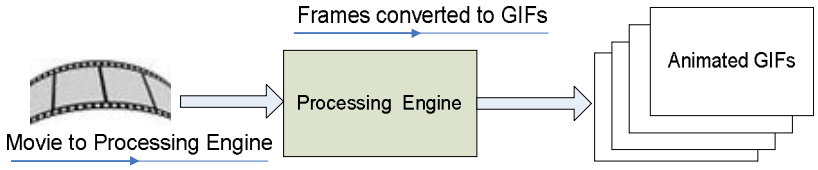

Figure 5: StreaMER Movie to Animated GIF Conversion Module

Figure 6 shows the overall Processing Load profile during the StreaMER Movie to Animated GIF conversion process.

Figure 6: Processing Load during GIF conversion

Figure 7 defines the percentage CPU utilized by all tasks during conversion of Movie streams to Animated GIF format.

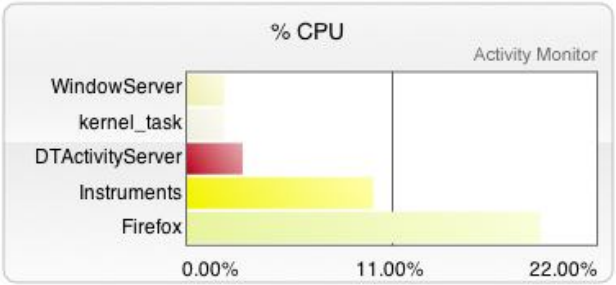

Figure 7: % CPU utilization by various tasks during GIF conversion

Figure 8 represents the total CPU Time for each running task on StreaMER Movie to Animated GIF conversion module during its operation.

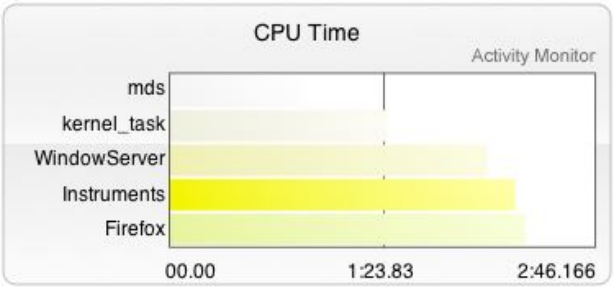

Figure 8: Total CPU Time for GIF conversion StreaMER

COST AND BENEFIT ANALYSIS

The following plus points of StreaMER are presented to show the competitive strength of StreaMER over other such solutions:

- **Internet Bandwidth cost reduction:** There is significant saving of internet bandwidth in terms of cost and network efficiency thus contributing in online internet time for end users.
- **No need of up gradation of end user Systems:** StreaMER efficiently adopts its media profile according to the availability of the hardware at the end user.
- **Open source solution:** By using open source components the StreaMER benefits from the development and improvement by the open source community.
- **More scalable as compare to Proprietary solutions:** Proprietary products are typically designed to work on specific bandwidth and load conditions while StreaMER can be scaled as per requirement by adding/upgrading its hardware easily.

- **Easy to adopt latest technological advancement:** The improvements and new developments done by the open source community are incorporated in the StreaMER by simply up grading its components.
- **Time saving for end users:** Time saving for end users due to flexible scheduler downloading and time shifting. This allows users to view the multimedia content whenever they are free.
- **User interactive interface:** The StreaMER's functionality allows the end users to interact with multimedia stream and can pause, rewind and fast forward as and when required.
- **Smooth playback of streaming media:** The media play back does not suffer from abrupt internet slowdown and frequent buffering.

The above points clearly indicate that the StreaMER will be a very strong competitor to the existing streaming solutions with its unique features.

JUSTIFICATION

The purpose of StreaMER is to present a much better and cheaper solution. With change in life style and the requirement of remaining informed about the latest events related to each individual. Moreover the lives are getting busier and busier with limited available time for entertainment and information gathering. In this scenario, people tend to utilize services of Multimedia systems connected to internet to fetch their required contents from different information sources for later playback. Another aspect of daily life is the use of video recording devices such as VCRs, DVRs etc. These devices allow delayed playback, pause, rewind, fast-forward and scheduled recording of multimedia contents.

Most of the software and hardware solutions available in market either do not perform all the functions that StreaMER does, or have hardware limitations or are proprietary. Such solutions are either not scalable or are dependent on the manufacturer for up gradation or introduction of new technologies. As StreaMER is based on open source technology, it is very likely that any advancement done by the open source community in its components is easily added to the StreaMER.

The usage of internet is increasing rapidly and the multimedia technologies serve as the backbone for information delivery services. The problem of limited bandwidth makes it difficult to get the media streams in smooth and efficient way for the increasing number of users. Our product StreaMER comes into the scene providing the functionality of Re-broadcasting the multimedia contents over the LAN without burdening the internet bandwidth. As StreaMER will capture all LAN requests for multimedia contents and queue them locally. So the download requests can be scheduled or queued to reduce the load on the network. The real time conversion/compatibility of live streaming contents to make it playable on the available players makes StreaMER very beneficial for the end users. StreaMER is equally valuable for PDAs and Smart phones.

COMPETITOR ANALYSIS

StreaMER combines the features of all existing multimedia content solutions available in the market with certain features that make it the leader in this market. The conventional softwares are geared towards media encoding, decoding with reliance on underlying network architecture including firewalls and bandwidth managers for their acceptable performance. The integration of Multimedia trans-coder, network streaming architecture and task scheduling framework gives StreaMER the leading edge over its competitors. The following section describes some other products in the market with their brief explanation and limitations compared with StreaMER. The contents of some of these sections are protected by copy writes of their respective owners. Their use in this document is for the sole purpose of comparison of their features with the features of StreaMER:

1. **TiVo by Teleworld** [11]

The TiVo services are to come-up with end user favorite television programs always ready for the user to watch beside this it also can be connected to internet via home network connection. The internet connection is for getting the stream for movies, photos and voice data to the user TV sets by the user clicks on remote. TiVo Digital Video Recorder works with standard Television or High Definition TV system using cables, antennas or satellite links.

Comparison: TiVo provides on-demand and live-streaming contents from internet to deliver them to the TV. As discussed earlier, this software relies heavily on the underlying internet connectivity and has no control over it. Moreover its functionality also depends on the TiVo Paid Services provided by the manufacture itself.

2. **Slingbox by Sling Media Inc.** [12]

Introducing the new technology of Slingbox SOLO the 3rd generation of Slingbox was launched in Sep. 2007. The products of Sling Media family were awarded several awards and gained the recognition which causes the drastic innovation in design and engineering in the field of media technologies. The group formed by Sling Media named as Entertainment Group in 2006 targeted the development of entertainment experiences for the media technology audience and business models with the mission of achieving goals beyond the scope of Slingbox.

That group caters the raise and management of the prime relationships with the content developers and the owners. The very first ingenuity of the group was to propose 'Clip plus Sling' technologies which will vividly change the way that consumers socialize with television. It actually enabling users to clip and share the selected segments online from the television broadcasted programs of their choice. Sling Media product family is distributed around five thousand stores in eleven countries of the world. Sling Media is stepping ahead in the field of media product development by merging innovation in digitalizing the daily life.

Comparison: Slingbox provides streaming of TV/Satellite or other information sources using hardware encoder module over the internet and LAN. This solution also lacks in the control of internet bandwidth and suffers from frequent buffering if the connection degrades. It also keeps optimizing the audio video quality within the available bandwidth. StreaMER does not compromise on picture and voice quality by utilizing its unique Dual Buffer technology for incoming and outgoing connections.

In [13] author defined an adaptive session to formularize multimedia stream. Resources were allocated with QoSmin during establishment of multimedia stream call and it could dynamically adjust its QoS parameters in [QoSmin, QoSmax] by PID to adapt the variations in resource availability during multimedia transmission. This not only met the QoS parameters required, but also improved the useful of resources. [14] Proposed an adaptive multi-media streaming service mechanism supporting regular and in continuity data transmission in mobile computing heterogeneous environment. The proposed idea of seamless provisioning of multimedia streams contains the strong buffering method with intelligent filtering and Quality of Service method. Authors use the concept of proxy for the implementation of this mechanism.

In [15] author identified the problems occurred in the technology of multi-media streaming and proposed the framework to handle such problems. Proposed idea base on TMO multi-media stream (MMStream TMO), streaming data types and TMO execution system for Multimedia Stream. They focused on the specified form of TMO which is TMO MMStream and real time multi-media streaming system modeling with MMStream TMO.

[16] Presented a technique for adaptive scheduling working with real time streams for MPEG-4. With this approach author targets the objectives for maximizing the concurrent multi-media streams without the loss in media playback. Considering the hold of soft real time characteristics for decoding MPEG4 multimedia streams are scheduled using resources for computation based on the mean execution time and their frame period. The proposed idea performance is compared with similar techniques by wide-ranging simulation experimentations.

Acknowledgment

The authors declare that they have no conflicts of interest in this research.

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