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Secured Transcode Enabled Layer 7 Proxy Handoff in Mobile Networks

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Abstract: In today's mobile era, multimedia applications need to communicate in real-time and are sensitive to the Quality of Service (QoS) they receive from the mobile network environment. For these applications to perform adequately and be widely used, QoS must be quantified and managed. Proxies can improve the quality of service of clients when the server proxy client networking architecture is applied to mobile networking environment. Since the mobile clients keep moving in the mobile networking environment, they should be able to switch to a new proxy dynamically in order to get the quality in multimedia streaming. In this paper, Application-layer Proxy Handoff (APH) is proposed to have applications be executed smoothly when mobile clients move in the server-proxy-client architecture. First, APH employs application-layer anycast to select one of the candidate proxies as the next proxy. Second, APH utilizes IPv6 multicast to switch the session from the original proxy to the next proxy smoothly. In order to meet the requirements of clients with multiple resolutions, transcoding enabled proxies are employed in this system. The transcoding enabled proxies perform transcoding as well as caching for efficient rich media delivery to mobile network users and also it optimizes the bandwidth requirement.

Keywords - Proxy handoff, Transcoding, Application Layer any cast, Quos.

I. INTRODUCTION

The internet is growing everyday; its popularity has brought heterogeneous devices together. Mobile users are accessing the internet with their desk tops, laptops, personal digital assistants as well as cellular phones. At the same time there is greater expectation from users to obtain rich media services via their access devices. When delivering multimedia streaming over the internet the two main issues to be dealt are mobility management and delivering quality of service in multimedia streaming to the clients with multiple resolutions. In order to deal with this, the server proxy client networking architecture is deployed in streaming service [1], [4] since the proxies are able to improve the transmission quality. In the server proxy client networking environment, if a mobile user keeps changing its location and wants to get streaming service all the way, it is not necessary for the mobile host to be connected to the same proxy for receiving data from the starting point of one region to ending point of another region. If it is still connected to the same proxy, it results in longer transmission latency and the quality of streaming service also becomes worse gradually. In this case handoff at the application layer called Proxy Handoff or layer 7 handoff [8] should be adopted.

To resolve this kind of layer 7 handoff, a new mechanism called Application layer Proxy Handoff (APH) is proposed to deal with switching from one proxy to another. The proposed APH is devised in the IPV6 wireless mobile network environment. Two features that APH adopts and utilizes are 1) Application layer anycast [5] and 2) IPV6 multicast. Application layer anycast is used to select the appropriate proxy when a mobile host is getting worst service from the current proxy. IPv6 multicast is utilized to transmit the requested multimedia data from the server to the corresponding proxies. Proxies used in this system are transcoding enabled caching proxies in order to provide service to heterogeneous mobile devices.

Depending on the connection, speed and processing capability of an end user, the proxy trans-codes the requested multimedia stream into an appropriate format and delivers it to the user. One potential advantage of trans-coding enabled caching is that the content origin servers need not generate different bit rate versions [3]. Moreover heterogeneous clients with various network conditions can receive multimedia streams that are suited for their capabilities.

The remaining part of this paper is organized as follows. Section 2 describes the system architecture of APH. Section 3 describes the Handoff management. Section 4 has the detailed operational procedure of APH. Section 5 gives the experimentation results. Section 6 concludes this paper.

II. APPLICATION LAYER PROXY HANDOFF: SYSTEM ARCHITECTURE

The system of APH can be divided into three levels, i.e. the server level, the proxy level and the client level. Fig. 1 depicts the system architecture of APH.

A. Server Level

The server level is composed of a number of Media Clusters (MCs). Each MC plays the role of a service provider and provides multimedia streaming service to the internet. There are two kinds of servers in an MC
1) Administrative Server (AS) and
2) Media Server (MS).
An AS is in charge of verifying clients using the AAA (Authentication, Authorization and Accounting) operation. If a client wants to request a multimedia stream from an MC it should send a request message to the corresponding AS via a proxy server. Once the client passes the AAA operation of the AS, it can get the requested stream from one MS of the same MC.

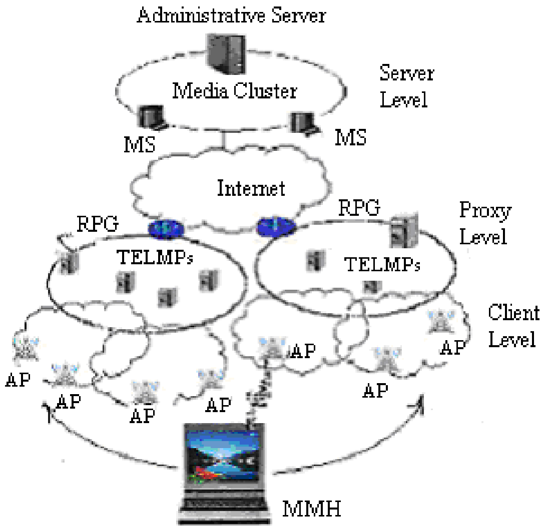

Fig.1 The System Architecture of APH

An MS is responsible for
1) Storing Multimedia files and
2) delivering the requested streams using multicast to corresponding proxy server.

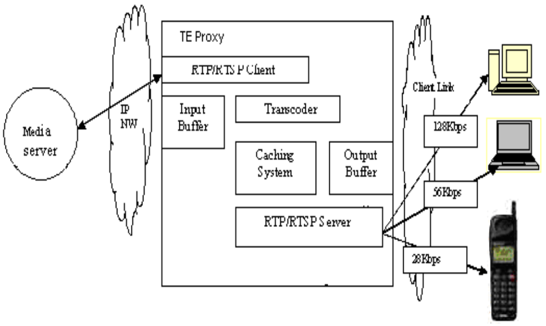

Fig.2 Components of Transcoding enabled caching proxy system

When a multimedia stream is requested from an MS, the multimedia stream is assigned a multicast group for transmission. If the same stream is requested via the same proxy server in different time points and the time interval between two requesting times is longer than the length of a stream that can be cached in a proxy, it is delivered by different multicast groups. Suppose if the same stream is requested via different proxies almost at the same point in time, it is delivered to the corresponding proxies using the multicast group for saving bandwidth.

B. Proxy Level

The proxy level is made up of many Transcoding Enabled Local Mobile Proxies (TELMPs). TELMP consists of the components shown in Fig 2. An RTP/RTSP client is built into the proxy to receive the streamed content from the media server. The received stream is put into the input buffer. The transcoder continuously pulls bit streams from the input buffer and subsequently pushes the transcoded bits out to output buffer. The proxy caches the content either from the input buffer or the output buffer while the transcoder produces the content. Hence, an RTP/RTSP server is built to stream the video to the end user. The data in the output buffer is obtained either from the transcoder or the caching system. The size of the input and output buffers can be small given that the transcoder processes the video data in a streamlined fashion. The speed of the process, i.e., the transcoding bit-rate, is defined as the number of bits the transcoder generates per minimum of the server link and the client link bandwidths, the transcoding process does not significantly increase the end-to-end delay.
The Transcoding enabled proxies dynamically transcode multimedia streams to different variants to satisfy the end users in heterogeneous environments [7]. Each variant is a version. If version x can be obtained from transcoding version y, then y is a transcodable version for x. Conversely, version x is the transcoded version of y. The variation in versions delivered to the client may not be transparent to the end user. The end user specifically asks for a certain version of an object based on the awareness of ones connection and display device. The proxy then transcodes and delivers requested version to the end user.
The TELMP utilizes compressed domain transcoding techniques. In compressed domain transcoding, the input multimedia stream is only partially decompressed. Rate adaptation is performed in the compressed domain while the motion information is reused. This approach considerably improves the processing speed over the conventional decode-and-re-encode approach. The proxy level is responsible for

1. Receiving multimedia stream from an MS using multicast.
2. Caching the received stream.
3. Transcoding and delivering the requested stream to Clients with multiple resolutions using unicast and
4. Supporting the proposed APH

Each TELMP would cache parts of the multimedia in order to reduce the response time of the next same requests. Each TELMP has its own service area; TELMPs having the same service area are combined into a Regional Proxy Group (RPG) and share their workload.

When a client requests a multimedia stream via a TELMP four conditions may occur.

- The first condition (cache miss) is that the TELMP has no available cache for the requested stream. Thus, the TELMP would join the corresponding multicast group in order to receive the requested stream.
- The second condition (exact hit) is that the TELMP is giving service to a client, if the same transcoded bit stream is requested by another client, and the difference of the requesting time between two clients is shorter than cache length of a stream, then TELMP can deliver the available cache to the new client immediately without requesting a new stream from the MS, i.e. without joining a multicast group.
- The third condition (transcode hit) is that requested stream is available in the cache and its transcoded version requested by the client is not available. In this case, cached content is transcoded and delivered to the client.
- The fourth condition is that the TELMP is serving another client but the difference of the requesting time is longer than the cache length. Hence, the TELMP must request the stream from the MS by joining a new multicast group.

C. Client Level

The client level consists of many Moving Mobile Hosts (MMHs). An MMH is responsible for 1) requesting and displaying the media stream and 2) controlling the process of APH. Since MMHs can move to anywhere at any time and no servers or proxies can predict the next location exactly, MMHs play the best role of being the core of APH. For example, if an MMH moves to another subnet, it should check whether it is still in the service area of the original TELMP or not. If the MMH is out of the service area of the original TELMP, it will start to perform the procedure of APH and then get service from the next TELMP.

III. HANDOFF MANAGEMENT

In this system of APH, mobility management is the key concern that needs to be resolved. The following section deals with AP (Layer 2) handoff, IP (Layer 3) handoff and proxy handoff.

A. AP Handoff and IP Handoff

When a MMH moves from the radio coverage of one AP to the other one, the MMH needs to change the associated AP. In this way, the MMH can continuously access the Internet through the wireless interface [2]. By constantly monitoring the signal qualities of the current wireless link, MMH can query the surrounding APs and switch to a suitable AP actively when the current signal quality falls below the minimum defined value. After AP handoff, if the new AP is associated with a new subnet, MMH's IP address should be changed and thus the corresponding RPG should be informed of IP update. After AP handoff, IPv6 protocol stack in MMH is notified by a local event that can trigger IP handoff. Then, the IPv6 protocol stack starts to use the address allocation mechanism to get a new IP address. Finally, MMH sends the IP update message to the corresponding RPG so that the media session will be in progress.

B. Proxy Handoff

In the architecture of APH, the TELMPs within the same service area compose an RPG and share their workload. Although these TELMPs belong to the same RPG, each TELMP provides different quality of services for each MMH. Once an MMH moves to a new subnet that is in charge of another RPG, all TELMPs in the new RPG become candidate TELMPs and the MMH must select one of them as the next TELMP. The selection process is performed using application layer anycasting [5]. First, the proxy selection scheme utilizes IPv6 hierarchical addressing [6] to group the TELMPs within the same service area into an RPG. Then, each RPG is regarded as one anycast group. Using the IPv6 anycasting technique, a packet sent to an anycast address, which represents an anycast group, is routed to the "nearest" node. This kind of anycast occurs in the network layer and the meaning of "nearest" is the minimum distance of a routing path from the sender to the members of the anycast group. Using the application-layer anycasting technique, a packet sent to an anycast domain name (ADN), which represents an anycast group, is delivered to the "appropriate" node. The meaning of "appropriate" is defined by the user, who can define the metrics to select one node from the anycast group according to their requirements.

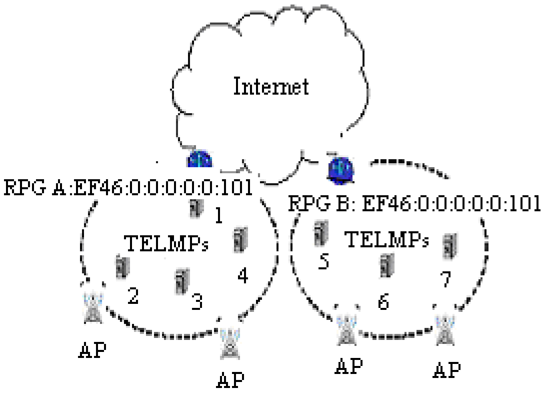

Fig.3 ADN Mapping Paradigm

The ADN can be a set of unicast or multicast IP addresses. Clients interact with the members in an anycast group via sending a request to the ADN. Once the members of the corresponding anycast group receive the anycast request, they respond with their metrics for selection. In this paper, an RPG represents an anycast group and the corresponding ADN of each RPG is a predefined site-local multicast address. The predefined site-local multicast address is unique. Once each LMP is set to provide service, it should join and listen to the RPG which is identified by the predefined site-local address.

For example, as shown in Fig. 3, there are seven TELMPs, denoted by TELMP 1 to 7, in which TELMPs 1 to 4 belong to RPG A and TELMPs 5 to 7 belong to RPG B. Two RPGs, RPG A and RPG B, are both represented by the site-local multicast address EF46:0:0:0:0:0:0:101. However, if an MMH sends an anycast request to RPG A, only the TELMPs belonging to RPG A, i.e., TELMP 1 to 4, can receive this request, but TELMP 5 to 7 will not receive it. On the contrary, if an MMH sends an anycast request to RPG B, TELMP 1 to 4 will not receive this request. Here it reserves scalability using a site local multicast address to map an ADN to an RPG. Since an MMH changes its attached subnet, it should not try to find out which RPG is in charge of the new attached subnet and the corresponding ADN because the predefined site-local multicast address is unique and predefined. Moreover, when more and more TELMPs are configured in a subnet, it is easy to adjust the organization of TELMPs by changing the size of a site. Once the size of a site has been modified, each TELMP is assigned to the new RPG according to its located subnet. MMHs would not recognize this change.

C. Anycast Metrics

To select the most suitable TELMP as the next TELMP, the following anycast metrics are defined in this paper. 1) Workload and 2) Round trip time. Workload is considered to keep the load of the TELMPs belonging to the same RPG as equal as possible. If an TELMP has too high of a workload, this TELMP may induce the long system response time for the connecting MMHs. In other words, workload is considered to avoid that one TELMP serves too many MMHs which results in the long system response time.

Round-trip time is considered to measure the transmission condition between an MMH and a TELMP. Since multimedia streaming service is sensitive to network delay and network congestion, the long round-trip time means the long transmission path or the congested transmission quality. That is, an MMH is assumed to get a better transmission rate from TELMP A when the round-trip time between the MMH and TELMP A is shorter than the one between the MMH and other TELMPs. Based on the above two metrics, the following equation is formulated.

$$\text{Anycast Metrics} = \text{Min}\,(W * LOAD_i + (1-W) * RTT_i) \quad (1)$$

where i is some TELMP in an RPG, W ($0<W<1$) is the weight value, $LOAD_i$ denotes the workload of i, and RTT_i denotes the round-trip time of i. The TELMP with the minimum value of (1) is selected to be the next TELMP.

D. IPv6 Multicast

In this paper, the session recovery scheme of APH is proposed to recover the original session after selecting the next TELMP. First, the session recovery scheme utilizes IPv6 multicast to smoothly resume the session between the next TELMP and the MS. Using multicast not only has the advantage of saving bandwidth consumption, but also helps APH to perform smoothly. Fig. 4 depicts an illustrated session status during the APH process. In Fig. 4, the MMH receives packets 1, 2, and 3 via TELMP A before movement. Then, it moves to another subnet belonging to another RPG and selects TELMP B as the next TELMP. If TELMP B has already joined the corresponding Multicast group, the MMH can get the requesting stream immediately from TELMP B without waiting for the time of reestablishing a connection from TELMP B to the MS. Thus, it is important to properly control the time point of TELMPs joining or leaving the corresponding multicast group.

The four steps which must be executed in sequence are as follows:

1. The MMH should inform the next TELMP to join the corresponding multicast group.
2. The next TELMP sends an ACK message to the MMH after joining the multicast group.
3. The MMH terminates the service with the original served TELMP.
4. The original served TELMP stops sending media packets to the MMH and leaves the corresponding multicast group.

Then, it sends an ACK message to the MMH. If the four steps are not executed in sequence, some media packets may be lost.

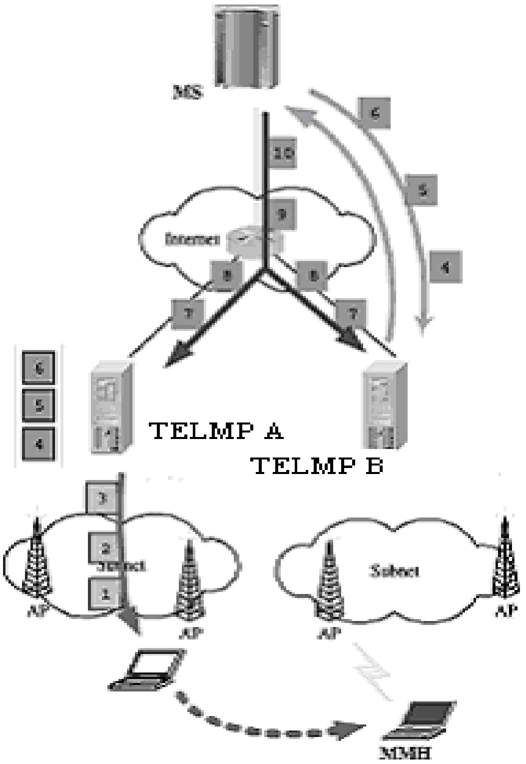

Fig.4 Session status during APH

E. Operational Procedure of APH

When the MMH moves out of the service area of the current TELMP, Layer 2 and/or Layer 3 handoff should be executed at first. After the Layer2/Layer 3 handoff, the MMH reconnects to the original TELMP and still receives the original session. However, since the MMH crosses the service area of the current TELMP, APH is performed. The proxy selection scheme and the session recovery scheme are executed in sequence. Fig. 5 depicts the message flow chart for the operational procedure of APH. The operational procedure is described as follows.

1. The MMH sends an any cast request to the any cast group (predefined ADN) for deriving the metric information.
2. When each TELMP of the next RPG receives an any cast request, it starts to calculate its workload.
3. Each TELMP reports its workload to the MMH.
4. When the MMH receives all of the responses, it selects the LMP that has the minimum value of (1) to be the next LMP. The MMH registers to the next TELMP and informs the next TELMP to join the corresponding multicast group in order to receive media packets continuously.

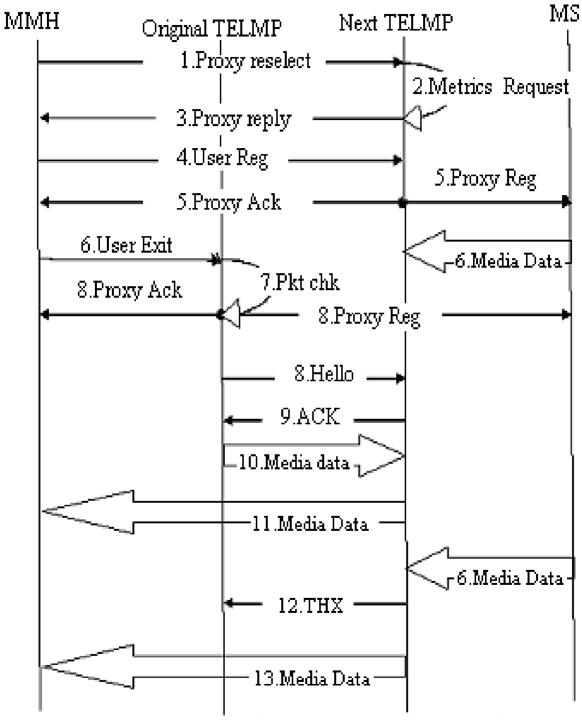

Fig.5 Message Flowchart for Operational procedure of APH

5. The next TELMP sends an ACK message back to the MMH after joining the corresponding multicast group.
6. The MMH informs the original TELMP that the MMH will stop receiving media packets from it.
7. The original TELMP checks its cache and identifies which packets are unsent
8. The original TELMP starts to perform the buffer forwarding process.

a. The original TELMP replies to the MMH and stop sending packets to it.

b. The original TELMP leaves the corresponding multicast group.

c. The original TELMP sends a Hello message to the next LMP in order to prepare to forward the unsent packets.

9. The next TELMP sends an ACK message to the original TELMP.
10. The original TELMP starts to forward all of the unsent packets.
11. The next TELMP sends the forwarded packets to the MMH.
12. The next TELMP sends the THX message to the original TELMP and terminates the connection between the original TELMP and itself.
13. The next TELMP sends the packets received from the MS to the MMH.

After the proxy handoff procedure is done, the system goes into the normal transmission procedure.

TABLE I. THE LATENCY OF APH

Background Traffic(Mb/s)	Average Latency(ms)
0	166
2	199.1
4	323.5
6	581
8	720

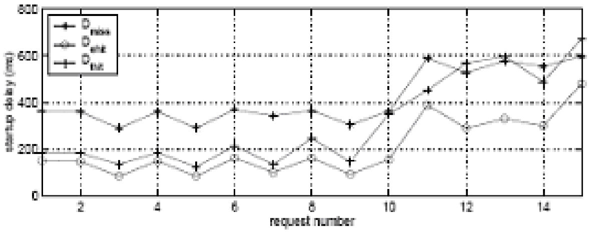

Fig. 6 Startup delay

V. EXPERIMENTATION

Two simple experiments were carried out in this system.

1) Measuring latency of APH and

2) Measuring start up latency which is another important metric in streaming media delivery.

The first experiment is to measure the latency of APH. The latency of APH is the time period between the time points of stopping receiving data from the original TELMP to the time point of receiving the first one of those packets that is forwarded from the original TELMP to the next TELMP. Table I depicts the experimental results. If there is no background traffic between any two subnets, the latency of APH is about 166ms. That is, the minimum buffer size in an MMH should be able to offer at least 166ms presentation time for preventing the MMH from interrupting the presentation. When the background traffic between subnets becomes heavier and heavier, the latency of APH is increasing. From this experiment, we can realize the cost for APH in different network situations and how much buffer should be stored in one MMH in advance.

The second experiment is to measure start-up delay of Transcoding Enabled system. In the server-proxy-client environment, the experiment is carried out with a sequence of 15 requests with five seconds apart, requesting for transcoding services on a test video sequence. Fig. 6 plots the start-up delay for each transcoding requests. Before the maximum transcoding capacity is reached, the average start-up delay for a miss (D_{miss}), an exact hit (D_{ehit}), and a transcode hit (D_{thit}) are 338 ms, 126 ms, and 172 ms, respectively. The experimentation results shows that transcoding enabled proxy improves the effectiveness, decreases the startup delay and APH latency.

VI CONCLUSION

In this paper, we have proposed a new mechanism called Application layer Proxy Handoff (APH). The goal of APH is to let applications perform L7 handoff smoothly when client keeps moving under the server proxy client networking architecture. In the system of APH, proxies perform transcoding in addition to caching to deliver quality of service to clients with multiple resolutions. Transcoding enabled proxies are useful for networks with heterogeneous environments as it transcodes the streaming object to the appropriate format based on user's networking and computing capabilities. Since the transcoding is done at the proxy level it reduces the traffic between proxies and the content origin or media server and also it reduces the user perceived latency.

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