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Adaptive Hybrid Transmission Mechanism for On-Demand Mobile IP-TV Over 4G

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ABSTRACT- In this paper, we propose an Adaptive Hybrid Transmission mechanism for On-demand Mobile IP-TV over 4G. Proposed algorithm utilizes hybrid mechanism which combines Multi-channel multicasting and unicast scheme to enhance not only service over service blocking probability but also reduce overall bandwidth consumption of 4G system which has very limited resources compared to 3G. An adaptive resource allocation algorithm is also proposed and is shown to achieve minimum blocking probability. In order to evaluate the performance we compare proposed algorithm against traditional unicast and multicast schemes.

Keywords- Adaptive, 4G, LTE, hybrid, MAC protocol

I.INTRODUCTION

As the demand for Internet and Internet-based applications grows around the world, Internet Protocol Television (IPTV) [1] has been becoming popular as it promises to deliver multimedia contents to users whenever they want and wherever they are. At the same time, with the creation of new applications and contents growing exponentially, multimedia streaming over wireless networks has emerged as an important technology and has attracted much attention with the convergence of broadcasting and networks, IPTV, a broadcasting service using the IP network, has become popular as a new business model. Furthermore, demand for IPTV service in wireless networks is expected to increase. The widely deployed IEEE 802.11 network is considered today as the de-facto wireless access network for what are known as last mile connections. It is a promising candidate for the delivery of Mobile IPTV [1]. Several reliable multicast MAC protocols have been proposed recently. However, little progress has been made in making any of these appropriate for mobile IPTV in terms of efficient network resource allocation. The primary aim of this paper is to present a new network resource allocation scheme for Mobile IPTV that maximizes the potential number of users. To offer QoS-guaranteed IPTV service, the TV viewing characteristics of user is analyzed by adopting a heterogeneous MAC protocol for a multicast service. Among the various IPTV services, the Video-on-demand (VOD) service, which offers watching a selected video at anytime and anywhere through the wireless access network, is taking the major service portion? Since users prefer to access content on-demand, rather than following a fixed schedule, most of the Video-on-Demand service is designed to deliver their video by unicast manner to meet the 'any time', 'on-demand' characteristics

From the network control perspective, it is simple and works fine when there is enough capacity and the service request rate is moderately low. However, if video requests are highly skewed, for example, the famous sports game or popular movies, then, large number of the unicast streams for the same content would be established and transmitted over the network. These results cause huge inefficiency of both media server and bandwidth consumption of wireless system which has very limited resources compared to wired networks. In case of mobile VOD [2] services, the bottleneck has been observe in wireless access network rather than multimedia server. To overcome this problem we are going for AHT mechanism" which is combination of both unicast and multicast transmission. In this mechanism the most popular video is transmitted by multicast transmission, and normal video is transmitted by unicast transmission. The decision of which contents are going to be transmitted by the multi-channel multicasting is decided by proposed adaptive resource allocation method that results in the lowest blocking Probability.

II. RELATED WORKS

In this section, we briefly review the existing VOD systems. Generally, VOD systems can be categorized into True-VOD(TVOD), which is based on unicast [2] transmission, and Near-VOD (NVOD), which is based on broadcast or multicast transmission, [4]-[7] how videos are delivered . In TVOD, the system reserves dedicated transmission channels from server resources to each client so that clients can receive video data without any delay via dedicated transmission channels as if they use their own VCR. However, may easily run out of the channels because the channels can never keep up with the growth in the number of clients. On the other hand, in NVOD, clients have to wait by some delay time because content is multicast over several channels with periodical cycle. The number of broadcasting channels is due to the allowable viewer's waiting time, not the number of requests. Thus, this approach is more appropriate for popular videos that may interest many viewers at a certain period of time. Clearly, the popularity of access pattern of video objects plays an important role in determining the effectiveness of a video delivery technique. Because different videos are requested at different rates and at different times, videos are usually divided into hot (popular) and cold (less popular), and requests for the top 10 20 videos are known to constitute 60 80% of the total demand. So, it is crucial to improve the service efficiency of hot videos. Until now, many NVOD methods have been proposed, such as the staggered broadcasting [3], pyramid broadcasting [4] fast broadcasting [5] staircase broadcasting [6] harmonic broadcasting [7] and etc.

These methods can classified into three main approaches to provide NVOD services, as batching [8]- [10], patching , and broadcasting . The batching approach collects a group requests that arrive close in time, and serves them all together with one channel. In patching, video request is firstly served by unicast stream and then joined back to a multicast stream. In broadcasting, the video is periodically broadcast into dedicated channel with pre-defined schedule. Most of VOD systems aim to improve the overall service transmission efficiency, addressing the concentrated request and abnormal burst request problems. As a result, due to their transmission characteristics, the NVOD is more capable for adopting unlimited clients access with broadcasting environment and the on-demand multicasting is applicable for the IP based network with high performance servers with good controllability over the wireless environment.

III. 4G APPROACH

Traditional live television (TV) broadcasting systems are proven to be spectrum inefficient. Therefore, researchers propose to provide TV services on fourth-generation (4G) long-term evolution (LTE) [2] networks. However, static broadcast, a typical broadcasting method over cellular network, is inefficient in terms of radio resource usage. To solve this problem, the audience-driven live TV scheduling (ADTVS) framework is proposed, to maximize radio resource usage when providing TV broadcasting services over LTE networks. ADTVS, a system-level scheduling framework, considers both available radio resources and audience preferences, in order to dynamically schedule TV channels for broadcasting at various time and locations. By conducting a simulation using real-life data and scenarios, it is shown that WMN [1] significantly outperforms the static broadcast method. Numerical results indicate that, on average, ADTVS enables substantial improvement to broadcast efficiency and conserves considerable amount of radio resources, while forgoing less than 5% of user services compared to the benchmark system.

IV.MOBILE IPTV VoD SERVICE SCENARIOS

According to ITU-T IPTV [11] service scenarios, VoD service is defined that "VoD is a video service which allows the end users to select and watch video content at any point of time. The end-user has full control over choosing which program or clips to watch and when starting to watch." A proposed service scenario for on-demand mobile IPTV is shown in Figs.2

1. Video content with its metadata and Content Protection data that are produced and managed by the content provider are delivered to the service provider.
2. The service provider prepares the content as per the agreement between the content provider and the service provider.

Fig.1.Mobile IPTV Over 4G

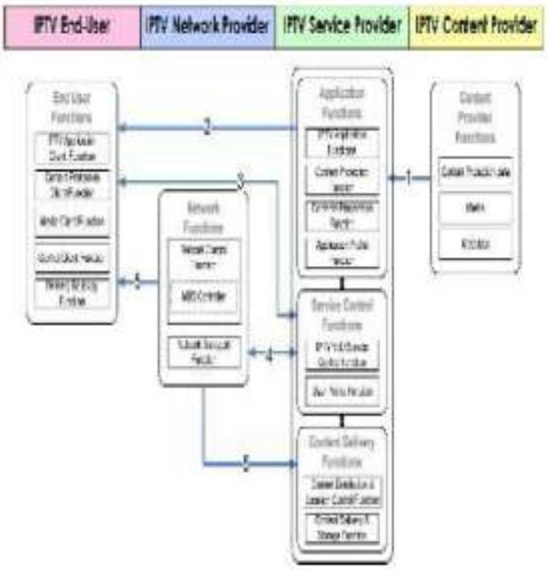


Fig. 2. Service scenario for mobile IPTV VoD.

3) As shown in Fig. 3, when an end-user selects a VoD content, the request(s) is sent to the service provider and checks that the requested content already sending by multicasting or not. If there Already exist multicast stream for the , then the server let the client know the video's multicast group address and then the client can join the multicast stream. This procedure may include negotiation (e.g., QoS, price, packaging option, etc.).

4)On the other hand, if there is no multicast stream for the video, the service provider interacts with the network provider checks within some threshold by newly updated arrival rate from IPTV VOD service control function-to decide this content is highly requested content or not. In this time, if it is not highly requested contents, it delivered by unicast manner. This procedure may include the network resource e reservation to guarantee the contracted service level.

5) Upon completion of the above step 4, the service provider supplies the content access information and the end-user.

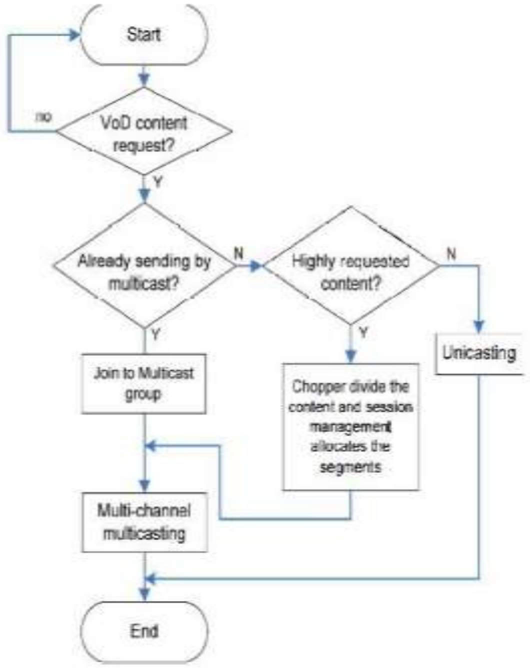


Fig. 3. Proposed service procedures for mobile IPTV VOD

V. RESOURCE ALLOCATION ALGORITHM

From an analysis of the TV viewing characteristics of users, two ideas are applied to the proposed resource allocation scheme.

1) Wireless Multicast Advantage (WMA)

The advantage of wireless multicast is exploited here. This originates from the broadcast nature of the wireless (spectrum) channel, where a node's transmission can be received by all neighboring nodes that lie within its communication range. This implies that regardless of the number of viewers that request the same broadcast channel, for example owing to its high popularity, the channel traffic can be delivered without additional network resources. This advantage of a wireless multicast is more attractive for IPTV service in a wireless environment compared to a wired network.

2) Heterogeneous MAC protocol

This study adopts both reservation-based and random access based MAC protocols to ensure QoS-guaranteed service and best effort service, respectively. As the current random-access MAC protocol in 802.11 based networks is not capable of providing QoS guaranteed multicast service, reservation-based MAC is required to reserve time slots for the most popular channels. In addition, the random-access MAC layer cannot reflect information from the upper layer, such as user characteristics. The heterogeneous MAC protocol [11] is highly promising when most viewers are using a relatively small number of popular channels and when they are not. If a particular channel has a large number of viewers, reserved time slots guarantee the quality of the channel traffic. However, if viewers are evenly distributed over a variety of channels, time slot reservation for unpopular channels is not appropriate due to the risk of bandwidth waste. A random access MAC protocol can offer an efficient resource allocation scheme for both IPTV service and best effort internet service.

This study assumes that a router has two network interface cards. The first is for the reservation-based MAC protocol for popular broadcast channels and the second is for a random access based MAC protocol such as CSMACA [Il] for unpopular broadcast channels and best effort internet service. First, broadcast channels are assigned in a descending order of popularity to network cards that operate on the reservation based MAC protocol. This allows QoS-guaranteed IPTV service to a large number of viewers even when the total number of users in the system is increasing. The number of channels to be assigned is based on the (spectrum) channel bandwidth. Other relatively unpopular broadcast channel viewers and best effort internet users access the medium by contention at the CSMAICA mode. As many viewers using popular channels with reserved time slots, the number of viewers of the remaining channels is decreasing. Therefore, although the random-access based MAC protocol is designed for the best effort service, a high quality of traffic delivery through the CSMACA protocol can be expected.

VI. THE HYBRID VOD TRANSMISSION MECHANISM

From the considerations on the existing schemes and IPTV service environment for VoD service, we propose a new hybrid transmission mechanism that takes the advantages and avoids the disadvantages from the existing methods. For our proposing hybrid mechanism, we also propose a new scheme, named as a multi-session multicasting that can deal with the concentrated and burst requests within the fixed boundary of the server's capacity. This multisession multicasting scheme takes the idea of video segmentation with multi channels (can be sessions in IP network) from the fast broadcasting (FB) scheme and then modified for on-demand based multicasting environment. By doing so, we can serve unlimited number of requests for very popular videos with fixed number of session over the best video allocation involves following steps.

Step 1: Sort the videos by their request popularity statistics. This popularity statistics is dependent on the service provider's policy for the cumulative statistical request history data calculation algorithm.

Step 2: With the given server's capacity, number of videos, service request ratios, and other environmental values, find the best video allocation ratio that minimizes the service blocking probability. The equation will be introduced in the later chapter.

VII .PROPOSED MULTI-SESSION MULTICASTING

In this chapter, we explain the multi-session multicasting scheme. The scheme is involved with three algorithms that are necessary for the server side and client-side. Specific algorithms are described in the following sub chapters.

A. Server-side Algorithm before transmission

Step 1: Calculate the number of sessions, ni, required for the i-th video, Vi, with length Li that meets the requirement for the VoD connection time, ct < IOsec by following equation:

$$\lfloor n_i \rfloor = Log_2\left(\frac{L_i}{ct}+1\right) \qquad (1)$$

Some examples of the number of sessions that is required for multi-session multicasting is shown in the Table 1.

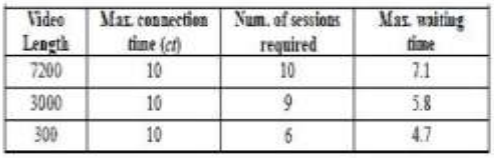
Step 2: Divide the video V, equally into Y'n, -1 segments, where ni is calculated number of sessions for V, from the step I.

Step 3: Allocate the segments to proper sessions. The segments are allocated continuously and periodically to its sessions from SI to Sl1i, by

geometrical series of I, 2, 4, .. 2A(ni-l) -1. The allocation is shown in the Fig. 4.
Step 4: Repeating the steps from 1 through 3 for all the videos allocated for the multi-session multicasting.

B. Server-side Algorithm/or transmission
Step 1: With client's request for the video which is allocated for the multi-session multicasting, if there is no multicast stream existing for the video v" server starts multicast streaming for V, with prepared n, streaming sessions
Step 2: If there is already existing multicast streaming for the Vi, then the server let the client to know the video's multicast group address and then the client can join the multicast stream by sending IGMP membership join message and receive the video sessions
Step 3: It there is no more client joined for the Vi, then server stops streaming and remain ready as prepared state with ni sessions.

TABLE I. AN EXAMPLE OF REQUIRED NUMBER OF SENSSIONS [SEC]



Video Length	Max. connection time (ct)	Num. of sessions required	Max. waiting time
7200	10	10	7.1
3000	10	9	5.8
300	10	6	4.7

C. Client-side Algorithm/or Playing
The For the client side, we suppose that the client's device has some disk space to buffer the selected video and apply the following steps.

Step 1: With the information of the selected video's multicasting address informed by the server, the client send the IGMP membership join message and start to receive the multicast stream of the selected video v,. Wait and begin to receive the first segment from the session, SI, at its first occurrence and also receive other related segments from the rest of the sessions concurrently with its buffer.
Step 2: As soon as the client starts to receive the first segment of the video, they can play the video in the order of segments with its consumption rate.
Step 3: Stop receiving the stream and send IGMP leave message, when they have received the (2An,-1)th segment.

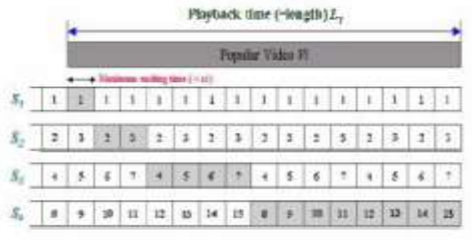


Fig 4. Overview of the Multi-session Multicasting scheme

VIII. SYSTEM MODEL AND NUMERICAL ANALYSIS

In order to analyze the proposed mechanism, we consider a group of K videos each of length L with different arrival rates respectively that are being transmitted using C channels. The popularity of these videos increases gradually with the index so that VI and Vk be the least- and the most-popular content respectively. The content's popularity (request frequency) ranking is calculated and given by the service provider based on their statistical data and their own service policy. For the numerical analysis, we assumed that request arrival for each video follow Zipf distribution [13] Based on the assumptions and video request model, we calculate the blocking probability by Erlang's loss formula with the state space S and M/MiC/C model.[14]

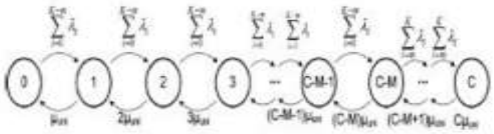
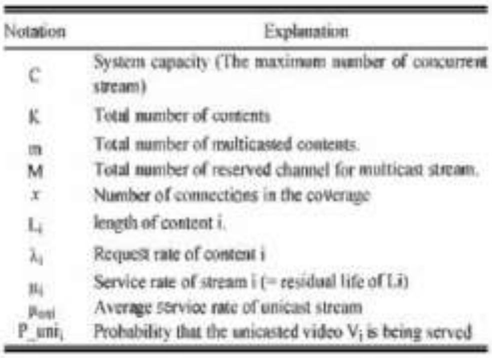


Fig. 5. Transition diagram for the proposed algorithm

Under those assumptions and parameters defined in Table II, we can model our proposal with MlG/c/c queuing model depicted in Fig. 3. Since the multicasted video requests do not suffer from the service blocking, we can model only for the unicasted videos to get the service blocking probability.

TABLE II
NOTATIONS FOR NUMERICAL ANALYSIS



Notation	Explanation
C	System capacity (The maximum number of concurrent stream)
K	Total number of contents
m	Total number of multicasted contents.
M	Total number of reserved channel for multicast stream.
x	Number of connections in the coverage
L_i	length of content i.
λ_i	Request rate of content i
μ_i	Service rate of stream i (= residual life of Li)
μ_{uni}	Average service rate of unicast stream
P_uni_i	Probability that the unicasted video V_i is being served

Let Px denote the steady-state probability that there are unicast streams, we can obtain

$$= \begin{cases} p_0 \prod_{j=0}^{x-1} \frac{\sum_{i=1}^{K-m} \lambda_i}{(j+1)\mu_{uni}} = p_0 \left(\frac{\sum_{i=1}^{K-m} \lambda_i}{\mu_{uni}} \right)^{x} \cdot \frac{1}{x!} & \text{for } 0 \leq x \leq C-M \\ p_0 \left(\frac{\sum_{i=1}^{K-m} \lambda_i}{\mu_{uni}} \right)^{x} \left(\frac{\sum_{i=m}^{K} \lambda_i}{\mu_{uni}} \right)^{C-x} \cdot \frac{1}{x!} & \text{for } C-M < x \leq C \\ 0 & \text{for } C < x \end{cases}$$

Since the steady state probability is not dependent on the service time distribution, but dependent on the mean service time, we calculate average service request rate as follow.

$$\mu_{uni} = \sum_{i=1}^{K-m} P\_uni_i \cdot \mu_i$$

$$Where \quad P\_uni_i = \frac{\lambda_i}{\sum_{j=1}^{K} \lambda_j}, \quad \mu_i = \frac{1}{L_i}$$

As a result, we can obtain the formulas for service blocking probability as follows:

$$P_{blocking} = \frac{\frac{\rho^{C-M}}{(C-M)!}}{\sum_{i=0}^{C-M} \frac{\rho^i}{i!}},$$

(4)

$$where \ \rho = \frac{\sum_{i=1}^{K-m} (\lambda_i \cdot P\_uni_i)}{\sum_{i=1}^{K-m} (\mu_i \cdot P\_uni_i)}$$

(5)

Since the proposed on-demand system divides contents into two subgroups-popular contents and others-such that the former subgroup is assigned M channels for multi-channel multicasting and the latter subgroup is assigned the remaining C-M
Channels for unicasting.

IX PERFORMANCE ANALYSIS

For the performance evaluation, we assumed some parameters with specific values. The content provider server can serve 100 concurrent channels, and there are 100 contents that their lengths are average 90 minutes (5400 seconds). The request arrival ratio varies from 5/60 to 20/60, and is calculated by Zipf distribution with skew factor 0.271 Based on the previous contents allocation, we show the performance of blocking probability of proposed mechanism compared with the existing mechanisms. As we can see from Fig. 6, the VoD service blocking probability increases as the total service request rate increases .. However, as service request rate increases, their blocking probabilities become different. In such case, our proposed algorithm can offer the low blocking probability.

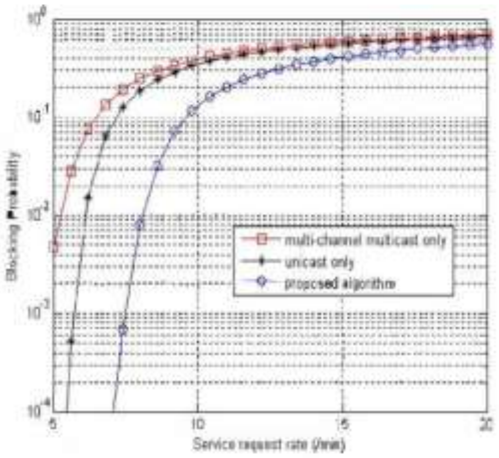


Fig 6 Blocking probability performance comparison between proposed and unicast scheme

X. CONCLUSION

In this paper, we have addressed the AHT algorithm that can efficiently provide mobile IPTV service. Proposed algorithm combined unicast and multichannel multicast mechanism that enhances not only service blocking probability but also reduces overall bandwidth consumption of the system. From the numerical analysis, we compared proposed algorithm against traditional unicast and multicast schemes. As a result, proposed scheme is able to improve IPTV service blocking probability

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