A New Framework Design for IPTV

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ABSTRACT

An IPTV is a system used to deliver television services to the consumers who are registered subscribers for this system. This delivery of digital television is made possible by using Internet Protocol over a broadband connection, usually in a managed network rather than the public Internet to preserve quality of service guarantees. In addition to this there is provision to include Internet service such as web access and Voice over Internet Protocol (VoIP). Currently, digital television is gradually replacing analogue TV. Although these digital TV services can be delivered via various broadcast networks (e.g., terrestrial, cable, satellite), Internet Protocol TV over broadband telecommunication networks offers much more than traditional broadcast TV. This paper first provides an overview of a typical IPTV network architecture and some basic server architecture design. This paper further argues that the availability of larger buffers in the network enables IPTV to better offer new services (in particular, time-shifted TV, network personal video recorder, and video-on-demand) than the competing platforms.

I. INTRODUCTION

Digital television (TV) is gradually replacing analogue TV. There are a number of competing methods to deliver digital TV services. Terrestrial, satellite, and cable networks have switched or are switching to transporting TV signals over digital channels. With IPTV services, users can enjoy VOD (Video on Demand), TV shopping, online game, karaoke, Internet chat, E-magazine as well as live TV broadcast. Among these, the most basic services offered by all IPTV service providers are live TV and VOD services. While live TV service is an alternative to terrestrial broadcast, cable TV, and satellite TV, VOD services provide movies including recent block-busters, a back catalog of films, and previously broadcasted TV programs in an on-demand manner. Fig. shows an overall architecture of the IPTV system including the two main IPTV services. New services such as video-on-demand, time-shifted TV, network personal video recorder, and others become practical. The technologies behind IPTV are the mixing of digital media and IP protocols. Original analog signals are digitized into strings of Os and Is which are then compressed to become manageable for transmission. In most IPTV systems, the primary underlying protocols used for IPTV are the Internet group management protocol (IGMP) and the real time transport protocol (RTP) or real time streaming protocol (RTSP) [3].

Internet TV is not the same thing as IPTV, although the key differences between these services are not clearly defined. Internet Television is quite different from IPTV in terms of the model for the consumer, the publisher and for the infrastructure itself. In Internet TV, the video publishing model is the same as the web publishing model, that is anyone can create an endpoint and publish it on a global basis. The transmission of video through open IP networks uses the public Internet, and the access of video can be achieved from any computer all over the world. As a result, Internet TV is sometimes referred to as "over the top" (OTT). By contrast, IPTV refers to the delivery of video services over closed IP networks which are supported by telecom companies. Besides, IP in IPTV stands for Internet Protocol, which means that the user does not have to log on to a web page to access TV programs. It is a method to transmit data over a managed network.

Live TV programs are encoded through an encoding server and then serviced to users with many interesting contents via a streaming server. Unlike live TV programs, video contents such as movies and recorded TV programs are stored on a storage server and are serviced in an on-demand manner. Users can view a list of titles and request to watch a specific title of video contents. The web server authorizes users or often makes up accounts, and the requested video contents are streamed to a specific user via streaming servers. Finally, the delivered contents are passed into the set-top box in the home, in which they are decoded and then displayed in multimedia appliances. Recently, with the advent of mobile IPTV technologies, IPTV contents can also be enjoyed with mobile terminals.

II. IPTV ARCHITECTURE AND PROTOCOLS

IPTV is an integration of video, voice, and data services using high bit rate broadband Internet access. In this section,
we will give a short description of the IPTV system architecture and protocols.

Architecture:

A typical IPTV system can be divided into four sections that are shown in Figure 1. All are generic and common to any vendor’s (or combination of vendors’) infrastructure [3], [4]. The heart of an IPTV system is the video head end or super head end. It is the point where the broadcast program and video-on-demand content is captured or ingested into the system. Typically, the head end can receive both analog and digital video feeds via satellite either directly from a content provider or an aggregator. A head end encodes video streams into a format suitable for IP transport and reception by an IP Set-Top-Box (STB). After encoding, video streams are encapsulated into IP packets and sent out over the network. All of the system content which consists of video, music, channel line up and data is transported over the service provider’s core network. The purpose of the core network is to provide adequate bandwidth for all the network traffic between service area and the video head end. Also, regional content and commercials can be inserted into the core network. Each of these networks is unique to the service provider and usually includes equipments from multiple vendors. At the network edge, the core network connects to the access network. The access network provides the network link from the core network to the consumer homes. It is sometimes referred to as “last mile” for network operators. The broadband connection from the core network and the individual household can be accomplished by various access technologies, such as different ADSL (asymmetric DSL) technologies (DSL, DSL2, DSL2+ and so on), VDSL (very high bit-rate DSL) technology, FTTH (fiber-to-the-home) as well as high-speed 802.11n wireless LAN. The home network is where the IPTV service enters the home and also where the distribution of data (voice, data, and video) among the IP devices in the home takes place. In the end the IPTV data will be delivered to the television via an IP STB, and Internet data to the home computers.

Fig. 2 shows the general system architecture of the multiple channel recording system. Basically, it consists of the following four parts: an IPTV server, core network, access network and IPTV clients with multiple channel recording capability. The IPTV server broadcasts multiple IPTV channels simultaneously based on the broadcasting program table. The core network transmits IPTV streams to the access network through IP multicast. The access network forwards the multicast streams from core network to the client network. In the above system, Passive Optical Network (PON) that provides 1.25G/2.5G downstream bandwidth is shown as an example of access network equipment. The IPTV client is receives IPTV streams, play one of the received channels, and record the selected channels simultaneously for future review.

Users can watch the recorded channels in their convenient time. With this system, when user would like to watch several channels that are broadcasted at the same time, he can watch one channel in real-time and choose another channel to be recorded in the local hard disk. After he finishes the current channel watching, he can switch to the recorded channel to review the program from the beginning. Thus, even the broadcasting time of some programs in different channels conflict, user will not miss any his favored channel.

III. PROPOSED SERVER ARCHITECTURE

In the proposed IPTV system, the server must maintain a list of media contents residing in other systems (media servers) and keep a dynamic classification of the contents, users, providers and multimedia content authors that are stored in its database. This classification is established and gradually refined based on the interactions between the clients and the multimedia contents. The IPTV system must also keep a profile of the users and their reactions (feedback) to the different multimedia contents in order to build and update the users preferences. The users interaction with the system will be made through an IPTV client that will allow access to all multimedia contents, display functionalities and basic interaction functionalities with the IPTV server. This client should provide the access to the system not only from common personal computers but also from TV system or mobile devices. The developed system should also enable real time visualization of the multimedia contents [4].

The prototype of the IPTV server was developed in order to enable the aggregation and management of a huge diversity of multimedia contents that is currently available and make them accessible, in an intelligent way, to an IPTV client system that will be responsible for all the process related to access and display of the multimedia data[6]. This availability of contents should take into account the convergence, interoperability and mobility of the
visualization devices, by using an heterogeneous and dynamic approach in terms of hardware and final user needs. Figure 4 graphically illustrates the global requirements of the proposed system. The server was built based on the Java language and is based on a distributed modular architecture, operating over the TCP/IP protocol, with multiple modules dedicated to specific functions and having the database system as the central and integrating element. The database system must contain all information that is necessary to the correct operation of each module and, consequently, of the system as a whole. The arrows corresponding to the connections between the different modules represent the direction of the dependences, while their labels represent the communication protocol [7]. The <<import>> stereotype label means that the dependency is internal (the functionality is embedded in the module), while the <<access>> stereotype means that the dependency exists because this module needs to access and/or modify remote data. Each module has an instance of the API that gives access to the IPTV database (IPTV Database Access). This API maps all entities in Java objects [8]. Figure 5 presents, in a graphical way, the framework of this API that enables access to the IPTV server database. Regarding the introduction of new functionalities or changing the existing ones, this intermediary layer of data access is extremely useful for the speed and correctness of the different processes, restricting the responsibility for errors and access problems to a single entity.

With the exception of the system remote management tool case, all data always flows between the module that requires it and the database, without any direct communication between the different modules. Each module has a XML configuration file (represented by the < = > symbol in Figure 3) that can be changed directly or through the system remote management tool. Four functional subsystems and one remote management sub-system were created.

The IPTV Server Core is the module that manages the XML communication and signaling over HTTP or HTTPS [9]. This module is exclusively passive, that is, it always answers to a received message but never sends a message without receiving the corresponding solicitation. Its internal logic of operations was conceived based on a multithreading policy [9]. Message delivery is assured by using HTTP (that runs over TCP). If one or more clients send messages simultaneously, the mutual exclusion of the operations and updates to perform on the database is assured by the Database Management System or the IPTV Server Core itself [10]. The Content Link Source module automatically captures and stores in the database the links to the multimedia contents and to all related information (author, date, content type, description, etc), besides starting their characterization using the initially available information. Currently, this sub-system uses APIs to search and access the sources of multimedia contents from directly supported content providers (like YouTube, for example) and RSS feeds in a completely generic way. The usage of the RSS protocol allows to establish a standard communication between this module of the IPTV server and any source of multimedia contents.

The User Profile Learning is the sub-system responsible for the interaction with the database in order to create and refine the information related to the user profile and the other items classified in the database. The system was designed taking into account the possibility of using intelligent and dynamic learning not only for the users profile but also for authors, providers, contents and users groups profile. This dynamic learning is based on the correlation of all usage experience of a system user: discrete feedback about the contents that were seen by that user, correlation with other system users having similar profiles, correlation with the members of his virtual group of friends (if it exists), among other factors that can influence the profile of the system user. The construction of the users profiles can be directly applied on the automatic suggestion of contents, enabling a much more efficient methodology that the simple utilization of probabilistic mathematical models. Other information can be used to complement and improve the efficiency of the automatic suggestion methodology: knowledge on the user areas of interest, user geographical position, meteorological conditions at the user location, the content visualization hardware, user language knowledge, user gender, age and profession, time instant of the service requirement, among other variables [11]. The system will store all this data for posterior correlation and synthesis. This data, together with information stored in the database for the same user, will be used to refine the knowledge about the system user. The functional sub-system that can be considered as the critical point of the IPTV server is the IPTV Database, because it aggregates and centralizes all crucial information. MySQL was the selected database management system, using an object oriented access policy through the Java Hibernate.
IV. PERFORMANCE EVALUATION

To generate an aggregated IPTV traffic of IPTV streams, we recursively select streams from the set of the ordered five video streams {ICE, CREW, HARBOUR, SOCCER, and CITY} and each stream begins at a random start time within the first 0.5 s of the experiment. By mixing different video streams, we simulate the common scenario that different home users watch different types of TV programs. Of course, the five test video streams can be ordered in other ways. Table IV shows the statistics of the generated aggregated IPTV traffic with different numbers of IPTV streams.

System Capacity

We first measure the system capacity in terms of the number of IPTV streams that can be supported by a wireless home network using the IEEE 802.11b, the IEEE 802.11g, or the IEEE 802.11n standard. We show the throughput under different number of IPTV streams in Fig. 3. Numerical results are obtained by solving the corresponding CTMC using the Matrix-Geometric approach. Simulation results obtained by ns2 are included in the figure for comparison. The excellent agreement between the numerical and simulation results confirms the accuracy of our model. It can be seen from Fig. 5 that the IEEE 802.11b standard can merely support the two IPTV streams (the aggregation of ICE and CREW shown in Table IV) and the channel becomes congested when the three IPTV streams in Table IV are transmitted [11].

V. CONCLUSIONS

In this paper, we studied the performance of IPTV streaming over wireless home networks. We developed a new framework to model the IPTV traffic streams and the IEEE 802.11e MAC protocol. With the developed model, we investigated the system capacity, delay and jitter, and PSNR performance. Additionally, we performed simulation experiments using ns2 to validate our numerical results and further study the performance in other aspects. Our investigation shows that in general, the IEEE 802.11b standard is insufficient to support the IPTV application while the IEEE 802.11g standard is suitable. For the particular scenario we test, we show that IEEE 802.11b can only support up to two simultaneous IPTV streams while IEEE 802.11g supports up to six simultaneous IPTV streams. After factoring surrounding interference, distanced connection with a lower physical data rate, and higher quality, we expect that the IEEE 802.11b standard will soon appear as a bottleneck. As the demand for high quality streaming increases, a higher speed wireless home network, such as the IEEE 802.11n standard, is required.

REFERENCES

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