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Research on Audience Rating Statistics of Two-way Digital TV Based on OpenSSL

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Abstract

The drawback of the present various forms of digital program audience statistical method is that only the traditional phone questionnaire survey, the diary method or the artificial equipment is applied to counting the situation of watching program. By means of combining the timely recognized operation property of various digital terminals and automatic return viewing program feature, a new scheme is proposed to count audience situation for program in two-way digital television network. The main technologies and functions of the scheme are described by introducing audience information gathering mechanisms, security return protocol stack based on openSSL, fusion and automatic transmission and its appropriate statistical methods. Meanwhile, the development of the audience rating statistical system is provided, which is used by some program providers according to this scheme. The experiment and users' feedback show that this scheme in the lower hardware configuration digital terminals can promptly and accurately count the subscribers watching program and effectively protect audience view information.

Index Terms: digitial TV; two-way transmission; audience rating

1. Introduction

Audience rating for watching television is defined as the percentage between the number of subscribers (or families) who watch some channel or program and the total number of all subscribers in a specific period. The indicator of accurate audience rating is important for judging the broadcast effect of television program and improving the program. Besides, it is the basis for advertising investment. Therefore, it is significant for media industry to study audience rating. With the development of multimedia technology, especially the wide use of internet and mobile communications, digital programs are watched by all kinds of accesses, such as TV set with set-top-box, multi-media computer and 3G mobile. The statistical methods of traditional phone questionnaire survey, the diary way and the automatic survey instrument [1] are the most suitable for users in one-way radio & TV broadcasting network, however, they gradually expose some drawbacks during gathering and transmitting the basic view data. For example, The statistic result of phone questionnaire survey is highly subjective; the

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diary table method is mainly dependent on the memory of audience and leads to poor accuracy and low creditability; but the automatic survey apparatus method needs to install a special device, furthermore, and need the inspector get to users' home to collect view data, which is work-loaded and inefficient.

With the rapid development of all kinds of terminals for viewing digital program, they provide an excellent platform for audience rating survey. Compared to traditional statistical methods, these terminals have many unique advantages, including the accurate data collection, security transmission channel, real-time data back and easy operation. Therefore, a complete audience rating statistics scheme has been proposed for two-way digital television network.

The rest of the paper is organized as follows: In Section II, an audience rating statistics scheme for a two-way digital multimedia network based on OpenSSL [2] is presented, key technologies during the process of implementing application system according to this scheme are described in Section III, main functions and meaning about statistics system are given in Section IV. Conclusion of the present paper is given in Section V.

2. Audience Rating Statistics SchemE

2.1. *Basic ideas of Statistics Scheme*

The new scheme for digital television program audience rating is based on the radio & broadcast network, internet, wireless network technologies and embedded technology. Its basic ideas is that the digital terminals (e.g., computer connected to internet, IP set-top-box [3], active 3G mobile TV) with two-way communication automatically identify and record the current program viewed by subscribers, and send these information to the head-end audience data reception server by internal decode chips and special network devices (support the broadcast network, multimedia wireless network, or internet connection). The audience data reception server firstly preprocess them, for example, parse and check data packet from the terminals, then save them into database for the use of audience data management publishing server or audience rating analysis terminal, then count these data by the real-time or non-real-time way, and finally show their statistics and analyze results to the program providers or subscribers by the way of the report table, graph format, to achieve the purpose of program audience rating statistics. The scheme includes the following key steps:

(1) User digital program view terminal can automatically restart its internal data gathering unit and record the current program viewed by subscribers when the power is on, at the same time, it builds a two-way connection with the head-end data receiving server by a special network interface device based on security openSSL protocol stack.

(2) When user is watching program by operating remote control, the data gathering unit inside the terminal can record the current program viewed data, for example, channel name, event name (or program name), watching start time, duration, and the relevant terminal information (e.g., user or terminal ID) etc, then the transmission unit send them to the head-end data receiving server through security openSSL path according to the predefined data packet format.

(3) According to the programs and subscribers servers' information, the head-end data receiving server analyze the data packets from the view terminals, then generate some new program view records and finally save them into the program view information database.

(4) Audience information management publishing server (or audience rating analysis terminal) count the programs view information from their corresponding data table by the presupposed calculation method to get and analyze program audience rating.

2.2. *Statistics Schema Based on openSSL*

According to the above basic idea and the return property of two-way digital terminal, we propose a complete audience rating statistics schema on the basis of [4] which doesn't consider how to protect subscriber watching program private, it is shown in the following Fig. 1.
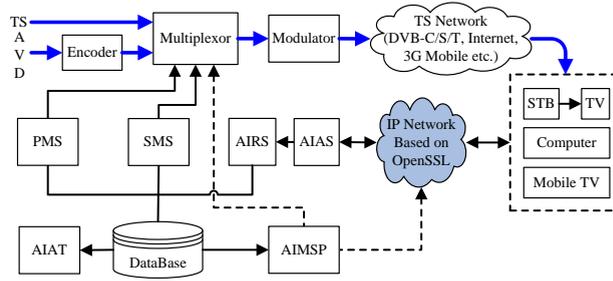
Figure 1. Schema of audience rating statistics based on openSSL.

In Fig. 1, the blue arrow describes the broadcast process of a typical MPEG-2 [5] transport stream (TS), the program source (TS, audio, video, and data etc) which be multiplexed is broadcasted to the digital terminal through a corresponding modulator (e.g., QAM, QPSK) and TS network (e.g., DVB-C/S/T broadcast network [6-8], Internet, 3G mobile wireless network), for subscribers to watch them. The closely related modules in this schema are explained in the following.

(1) *The digital view terminal*, a digital device can be used to watch program, for example, IP set-top-box, at the same time, this device is a starting point of a whole audience rating statistics system, and automatically connect with the head-end server, gather the audience data and return them.

(2) *Audience information authentication server* (AIAS), AIAS is mainly responsible for establishing a connection with a digital terminal device based on openSSL protocol stack, and verify its validity.

(3) *Audience information receive server* (AIRS), AIRS is mainly responsible for receiving and analyzing the data packets from a terminal device, and save them into database, it is the core of the whole audience rating statistics system.

(4) *Audience information management statistics publish* (AIMSP), this platform is mainly responsible for managing and count audience data, and it can transmit the statistics result to the digital terminal for user view it though two-way network.

(5) *Audience information analysis terminal* (AIAT), the AIAT deployed in the head-end can directly access database, and set the specific different statistics parameters by different requirements, obtain the analytical results of audience rating by report table or graph format.

(6) *Program management system* (PMS) and *subscriber management system* (SMS), the two parts are responsible for digital program and subscriber information management, the former provides the programme source for AIMSP, the latter provides the statistics parameters or the analysis of background data for AIMSP and AIAT.

(7) *Database,* this database server is mainly responsible for providing storage space for digital program, subscriber terminal and audience data information.

3. Key Technologies

From the audience data return flows in the Fig. 1, we can know that an audience statistical system includes four major modules: gathering audience data, establishing security two-way channel, data fusion and automatic transmission, and data statistics and analysis etc, so their key technologies are described from the technical aspects as follows.

3. 1 Gathering Audience Data Automatically

The subsystem of gathering audience data is the starting point of whole audience rating statistics system; it can obtain audience information from user terminal view devices. The key techniques including two parts: audience data structure design and gathering mechanism.

1) *Data structure design*.

Audience data serves as the available information of audience rating statistics, so terminal view devices must record the basic information which can identify user watch program situation, for example, terminal (or subscriber) ID, channel (or service) name, program (or event), start time, duration and network name. This information is also the major unit for defining audience data structure, which can calculate the various indices for the audience statistics. The terminal ID is obtained from terminal interface API defined by manufacturer and only recorded in order to save space here, the reason is that other background information about view terminals are also registered in SMS when subscribing the digital programs, such as user name, living area, sex, age, occupations. When being searched by subscribers, programs information can be saved into special area, so channel name is received from SDT [9], program name from EIT [9], start time of watching program is received from TDT [9], because TDT don't change constantly, in order to receive the accurate time, it is necessary to create a timer task which starts to run once it receives TDT, so that subscribers' watch time can be obtained from the second unit, the watch duration can be obtained from user stopping time or the start time of the next program, network name can be analyzed from NIT [9]. In addition, in order to reduce the record length, the changeable syntax is used, that is to say, each audience data component must follow the (*tag, length, value*) format.

2) Data gathering mechanism.

In order to gather audience information automatically, a gathering task need to be created in the terminal software firstly, the task is responsible for recording the program information watched periodically, in theory, it can accurately gather the data of when and what programs subscriber watch. But some view data need to be filtered, the reason is that too short duration is not significant for audience rating statistics. Suppose that the duration threshold of data gathering is λt, if a subscriber watch duration is less than λt, maybe the subscriber changes channel, so this data is invalid and should be discarded; if watch duration is more than λt, this gathering task records down all the audience data. Of course, the threshold value should be redefined by a subscriber through menu or by an alteration faraway command message.

3. 2 Establishing Security Return Channel

OpenSSL protocol achieves information secure transfer between two session sides through asymmetric encryption technology, it can implement the data transfer secret and completeness, and the session sides can identity each other. So the scheme in this paper establishes an audience data return channel based on OpenSSL, in order to create a secure connection between terminals and AIAS, A handshake process is required to complete identity identification and the key exchange between each other. When the handshake finishes, the session is established, two parties can encrypt and decrypt transmission audience data by the same session key, their communication protocol stack is as following:
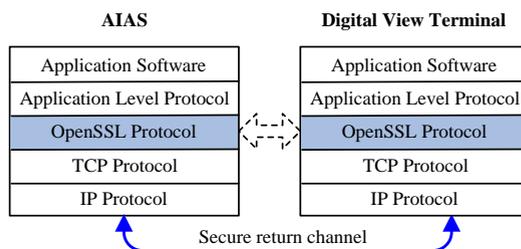

Figure 2. Security return channel protocol stack based on openSSL.

In Fig. 2, the communication task built on openSSL deals with requests by the jam way, all incoming communication requests will be stored in the queue with priority; the request with higher priority will be processed firstly.

3. 3 Fusion and Automatic transmission

To make full use of network resources, the data gathering task also combines a number of audience information records in accordance with certain rules, such as channel, column, the scope of special time, and merge these data into an openSSL packet, then send them to AIAS through the communication task automatically. When transmission completes, these area saved data in subscribers view terminals should be emptied.

The data package format is defined as following:
message_content {
message_tag   8 uimsbf
message_length   8 uimsbf
for (*i* =0; *i*<N; *i*++) {
text_char   8 uimsbf
}
}

3. 4 Data Statistics and Analysis

According to statistics theories, it is easy for us to calculate some evaluation indicators about program audience situation by the information received from the terminals and saved in PMS or SMS server. Audience rating should be computed in accordance with day, week, month and year, and can be shown to users by report. At the same time, audience rating should be analyzed based on subscribers' different characteristics (e.g., age, education level and occupation). For example, main formulas in our present system include:

(1) The average audience for a channel in specified time:

$$\overline{AudienceRating_C} = \left[\left(\sum_{i=1}^{m} T_c(i)\right)\middle/ T_{Channel}\middle/ N\right] \times 100\% \tag{1}$$

Here, $T_C(i)$ is the time user i watches the channel, $T_{Channel}$ is the actual time of the channel plays, m and N are the count of users who watch channel and the total count of users.

(2) The average audience for a program in specified time:

$$\overline{AudienceRating_P} = \left[\left(\sum_{i=1}^{m} T_p(i)\right)\middle/ T_{Program}\middle/ N\right] \times 100\% \tag{2}$$

Here, $T_P(i)$ is the time user i watches the program, $T_{Program}$ is the actual time of the program plays, m and N are the count of users who watch the program and the total count of users.

(3) Market share for a channel/program in specified time:

$$MarketShare_{C/P} = W/U \times 100\% \tag{3}$$

Here, W is the count of users who have watched this channel or program; U is the count of all users who watch television.

4. Mian Functions

The purpose of audience statistics system is to summarize, calculate and analyze the situation of subscribers who watch programs, and reflect subscribers' view conduct. Its main functions are as follows:

4. 1 Real-time Reference

Real-time audience data is very important for subscribers and program providers to accurately reflect current audience situation of program. For subscribers, the real-time audience data could well guide them to choose the programs they like, but not to switch channel without any intention; for program providers, they can reasonably adjust programs according to the attention of audience data, at the same time, program providers may put the current audience information in the hall so that better television programs will be generated.

4. 2 Curve Analysis

There are two ways for audience rating curve analysis. One is the real-time curve analysis; and the other is non- real-time curve analysis. Which way to be used can be selected by user, at the same time, user can also look into the program curve by time interval. It can be clearly shown that which channel gets higher audience rating in this time interval, or which channel gets the lower audience rating. Furthermore, the daily curve, weekly curve and monthly curve about audience situation are displayed for one channel or more channels. For example, the daily curve about CCTV News, CCTV1 and CCTV2 from China is shown in Fig. 3.
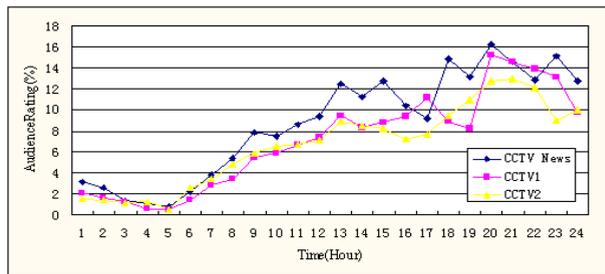

Figure 3.   Audience rating daily curve graph based on channel.

From the above curve, it is easy to see the audience situation of channels, programs or advertisements; it provides a good guide for programs schedule, evaluation and advertisements placing and so on.

4. 3 Report and Graph

The report and graph style can also show program audience information besides curve. For example, in our developed system, the report and graph of major channels monthly audience rating are shown in Fig. 4.

Audience Rating Statistis Table Based on Channel

| Channel No	Service Name	Audience Rating(%)	Audience Ranking	Stat Starttime	Stat Endtime
1	CCTV1	78.05	1	2010-09-06 18:28:38	2010-10-06 18:28:37
2	CCTV2	46.34	6	2010-09-06 18:28:38	2010-10-06 18:28:37
3	CCTV3	53.66	5	2010-09-06 18:28:38	2010-10-06 18:28:37
4	CCTV4	39.02	8	2010-09-06 18:28:38	2010-10-06 18:28:37
5	CCTV5	63.41	3	2010-09-06 18:28:38	2010-10-06 18:28:37
6	CCTV6	34.15	9	2010-09-06 18:28:38	2010-10-06 18:28:37
7	CCTV7	41.46	7	2010-09-06 18:28:38	2010-10-06 18:28:37
8	CCTV8	26.83	10	2010-09-06 18:28:38	2010-10-06 18:28:37
9	CCTV9	21.95	11	2010-09-06 18:28:38	2010-10-06 18:28:37
10	CCTV10	58.54	4	2010-09-06 18:28:38	2010-10-06 18:28:37
11	CCTV11	12.20	12	2010-09-06 18:28:38	2010-10-06 18:28:37
12	CCTV12	68.29	2	2010-09-06 18:28:38	2010-10-06 18:28:37

(a)
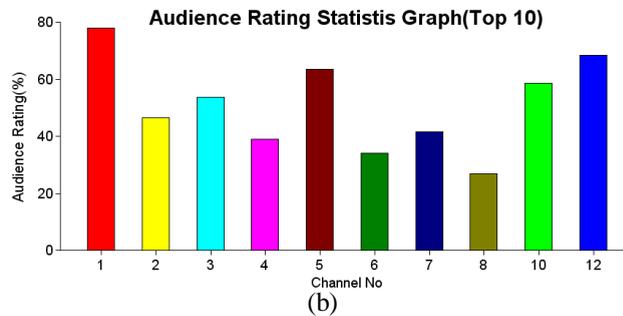
Figure 4. Audience rating tatistica table and graph based on channel.

4. 4 Information Publish

Apart from ATAI which provides program providers to look into the program audience quickly, AIMSP provides two audience information publish methods for the subscriber to understand current program situation.

(1) Through the existing digital TV broadcasting network platform, the audience information from head-end database is firstly encoded into transport stream format and injected into multiplexer, and real-time sent to terminal view device in the light of data broadcast mechanism.

(2) Deploying web server in the head-end, the audience information from it is published by adopting HTTP protocol, and then issued into internet in real-time or regular manner to provide terminal subscribers for reference.

5. Conclusions

In this paper, a new audience rating statistics scheme has been presented for two-way digital program network by means of embedded real-time operation system, computer network and radio & TV broadcast network technologies. The application system developed based on this scheme can timely gather audience view information from the user's digital terminals (for example, digital set-top box), and automatically combine and return them to head-end's AIRS and AIAS. Furthermore, AIAT add up these view information saved into database to get the accurate audience rating for the digital programs. The scheme well solves some problems in the existing statistics system, such as high terminals cost, slow response time and low automation. It is important that all kinds of digital view terminals can be widely used and can achieve the census benefits (to all digital program users) and avoids the inevitable errors from the sampling survey. The present study can further reflect the universality, objectivity and representativeness of the audience rating statistics.

Acknowledgment

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