Field Tests of Two-Way Television Audience Measurement System

Tunde Aina, *Member, IEEE*[*‡], Zhang Ye, *Member, IEEE*[*], Zhenzhong Dai[†], Cao Jianghui[†].

*School of Electronics and Information Engineering, Harbin Institute of Technology, China,

†Star Software Technology Company Ltd. Beijing,

‡Nigerian Television Authority, Headquarters, Abuja

***Abstract*—Peoplemeters are used in Television Audience Measurement systems to determine and record when TV receiving equipment are switched on and to which channel they are tuned, some more sophisticated systems may be able to determine which member of each household are actually in the audience at any particular time. Audience viewing data can now be obtained in real-time as different systems have been developed that can send user behaviour over various telecommunications networks as they occur. Landline telephone and data links have proven to be reliable and cost effective for transmitting audience user behaviour however this basic infrastructure is inadequate in many African countries. The two-way meter in question consist of a Viewer Behaviour Acquisition and Storage Module integrated with a GSM 3G modem for data connectivity. The Viewer Behaviour Acquisition module is embedded in a special Digital Terrestrial Television set top box (STB). A 3G data modem is integrated with the Acquisition Module, it has a standard size GSM sim card slot which is not accessible from outside the set top box.**

This paper is an analysis of the results obtained during experiments in the lab using an Ethernet local area network and on the field using a GSM Network. Network delay, data loss and amount of data generated were all within tolerable limits,

Key words: DTV and broadband multimedia systems, Field trials and test results, Convergence of broadcasting and Broadband Wireless

I. INTRODUCTION

Television Audience Measurement (TAM) is the process of collecting storage and analysis and presentation of viewer behaviour in broadcast television. Audience measurement data is of interest to senior management of broadcast stations, Governments, Advertisers, Advertising Agencies, Academics and the general public[1]. Television Audience Measurement provide many indicators of audience behaviour and consumption of broadcast television; some of these indicators include TV Ratings which enable broadcasters and advertisers determine advertisement rates of individual programmes or stations. Television broadcasting commenced in the industrialised countries in the 1920s[2], in the United States television was advertisement driven consequently advertisers were the first to see the need for an independent feedback audience viewing behaviour[2].

Television broadcasting is largely one-way, it therefore poses a big challenge how to obtain data on viewer behaviour in order to be in a position to determine various indicators which are of interest to the various players in the broadcast chain. In the early days of television in the United States of America, audience was measured by counting the letters written by viewers to estimate the viewership of a particular programme or station[2].

Television Audience Measurement has been undertaken using different methods from the early days of TV but has evolved over the years from the simple manual method like the diary method to more sophisticated electronic systems in use today[3]. Modern TV Audience Measurement Systems in general usually consist of a method of obtaining and recording data[4], a method of transmitting the data from the viewers' homes to the data centre and a method for analysing and presenting the data. This paper shall focus on field tests of transmission of Television Audience Measurement data over wireless telecommunication networks from the terminal to the data centre.

II. ONE WAY TELEVISION AUDIENCE MEASUREMENT SYSTEM

Audience measurement systems usually have a method for recording, collecting and analysing viewer behaviour data for presentation in a form that can be utilised by broadcasters, advertisers and agencies. For many years, People meters have had the capability to transmit viewer behaviour data in real-time from the viewers' homes to the data centre of the collecting organisation using telephone lines and other data links.

Unfortunately in Sub-Saharan Africa, landline telecommunications networks are still relatively under-developed and with limited reach, consequently it was a big challenge to transmit viewer behaviour data from the viewers' homes to the data centre for analysis in real time.The One-way Television Audience Measurement System was developed to enable collection of data from viewers' homes at least one every month for analysis; this was a very tedious and expensive process because an engineer had to pay monthly visits to all the sample homes to collect the data written onto a USB flash drive and take to the data centre for analysis.

- The terminal is located in the viewers' homes
- The Back-end system is located in the data collection centre, in this case the head-end of a Digital Terrestrial Television Network.
- The Viewing Behaviour Acquisition Module collects the viewing behaviour data which consist of viewer identity, the start time of watching a programme, when viewer switch channels and the corresponding channel information, specific operations including but not limited to: watch broadcast TV, broadcast anomaly, back to normal play, enter the menu, exit the menu, enter other business, standby and similar operating data.
- The Viewing behaviour Storage Module stores the Viewing Behaviour data to a USB external storage device in the form of files.
- The Data Processing Subsystem is responsible for handling the basic data, including programme and channel information, the sample viewer information, viewing behaviour data and the other data.
- The Statistical Analysis and Display Subsystem performs statistical analysis of the above basic data, and displays the final result in the required format
-

A. Technical Description of The One-Way TAM System

The one-way TAM solution consist of two parts; a terminal system in the viewers' homes and a back-end system located in the data center. The terminal system consist of the Viewing behaviour Acquisition Module and the Viewing Behaviour Storage Module all integrated in the digital television decoder while the back-end system consist of the Data Processing Sub-System and the Statistical Analysis and Display Sub-System. Data is transfered from the terminal to the back-end monthly and manually using USB flash drives, fig 1.0 illustrates an overview of the one way TAM system.

B. Shortcomings of The One-Way TAM System

The one way TAM system collects viewer viewing data and writes this data onto an atached USB flash drive which is physically collected by engineers once every month for analysis at the data centre. A major disadvantage of this method is that viewer viewing behaviour cannot be obtained in real-time, infact it was only possible to obtain data that is at least one month old. Another disadvantage was that this system was very expensive and cumbersome to maintain; A typical city has a sample size of around 200 homes, sending engineers to 200 homes every month just to collect data written onto USB flash drives was a huge task in terms of time and cost. Furthermore, monthly visits to homes is an intrusion on the privacy of viewers who are part ot the sample population

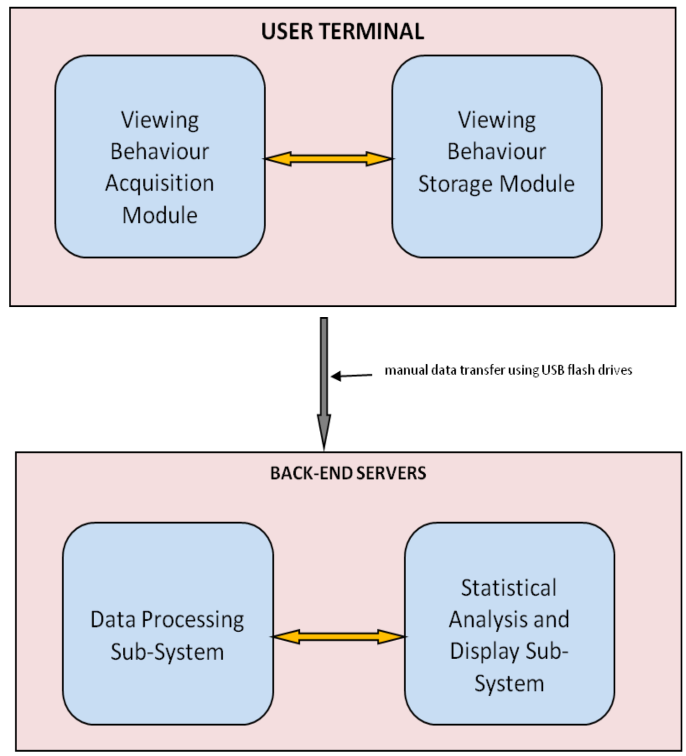

Figure 1. One Way TV Audience Measurement System.

III. FIELD TRIALS OF TWO-WAY TELEVISION AUDIENCE MEASUREMENT SYSTEM

The two-way TAM system is similar to the one-way system in terms of function, the main difference is the addition of a GSM 3G module with a sim card slot for the purpose of data connectivity as illustrated in figure 2.0. This connectivity enables the transmission of viewer behaviour data in real-time from the viewer terminal to the data centre thus, TAM indicators can be ready within a few minutes of events occuring, maintenance cost is less and engineers do not need to intrude into viewers' privacy through monthly visits.

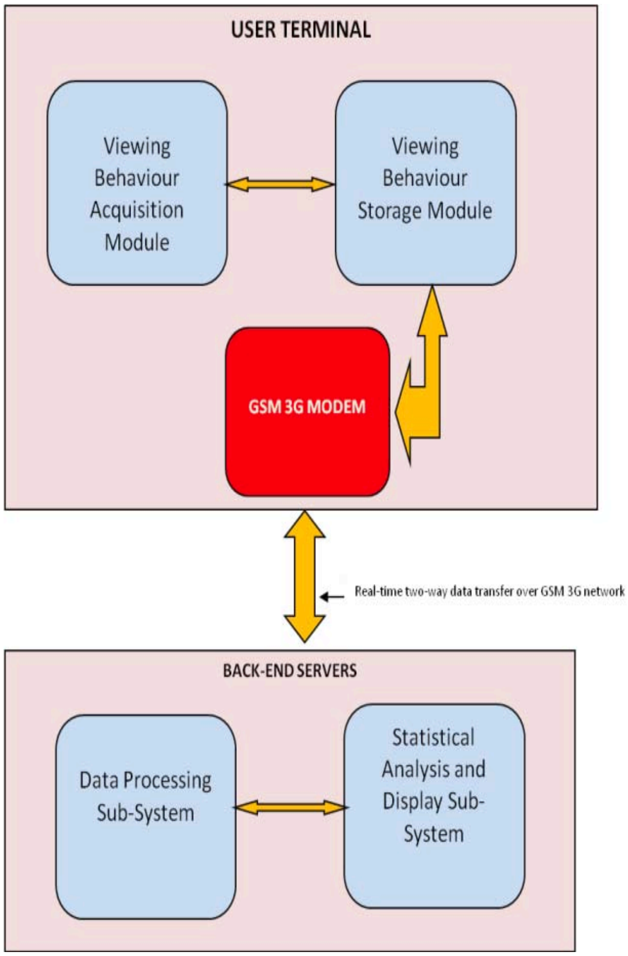

Figure 2. Two-Way TV Audience Measurement System

A. Objectives of The Field Trials

The field trials of the two way Television Audience Measurement System had the following goals;

- Determine if the communication channel, in this case GSM data connection, is reliable by calculating network delay and data loss if any.
- Determine how much TAM data is generated by the viewer terminals
- Estimate data cost based on standard data charges by the GSM operators

B. Equipment Deployed

This field trial consist of two sets of equipment, a special viewer terminal or decoder and servers located at the head-end of the Digital Terestrial Television network. The viewer terminal is a special DTT decoder with an embedded Audience Measurement module equiped with a GSM 3G module with sim card slot. The following equipment was deployed on the server side;

1) Electronic Programme Guide (EPG) server
2) Database server
3) Web server
4) Analysing server.

C. Indicators Measured

The purpose of this tests is to determine if GSM network is reliable for use in transmitting viewer behaviour from the viewer terminal to the data centre. The following indicators were measured;

- Network Delay- to determine the average time for a data packet to travel from viewer terminal to data centre, Each packet has a time stamp attached from the viewer terminal and the server keeps a log of the time each packet is recieved.
- Data loss-to determine if data is lost in transit , this is achieved by adding sequence numbers to each packet and checking the received packet for lost packets.
- Amount of data generated-GSM network are third-party communications network with costs depending on data consumption, it was necessary to estimate how much data is transmitted by the system to be able to determine the most cost effective data plan.

D. Lab Simulation

In order to study how the two-way TAM system will behave under labarotory conditions, tests were performed to measure the afore mentioned indicators namely delay, packet loss and amount of data generated by the system. In the lab set-up, the TAM system consist of a server side and the terminal side as earlier illustrated in fig 1.0 above. The TAM software is installed on a desktop PC while the server side has 4 different software performing different functions. The sequence of events is as enumerated below;

- First terminal and server time-sychronise with a time reference server
- Terminal and server initiate a handshake session
- The terminal sends a heartbeat IP packet every 5 minutes to indicated that it is turned on.
- The terminal sends TAM data every minute to the server in the form of UDP packets.

The behaviour of the TAM system can be observed in Fig. 3.0 which is a Wireshark capture from the ethernet port of the desktop PC running the TAM software, the first eight packets, that is, frame number 186 to 8545 are Network Time Protocol (NTP) Packets between terminal and server used to time-synchronise both of them with a time reference server. The terminal and server then perform a hand shake as can be seen with frames 9211 and 9212. Frame number 11736 is TAM data which is sent every minute from port 55585 of the terminal desktop computer. Frame number 23171 is a heartbeat packet with a time of Apr 15, 2014 08:44:48.340769000 W. Central Africa Standard Time and is sent from port number 52749 of the terminal desktop computer. The next heartbeat is frame number 35897 with arrival time of Apr 15, 2014 08:49:48.319638000 W. Central Africa Standard Time, this is five minutes after the previous frame which is the expected behaviour.

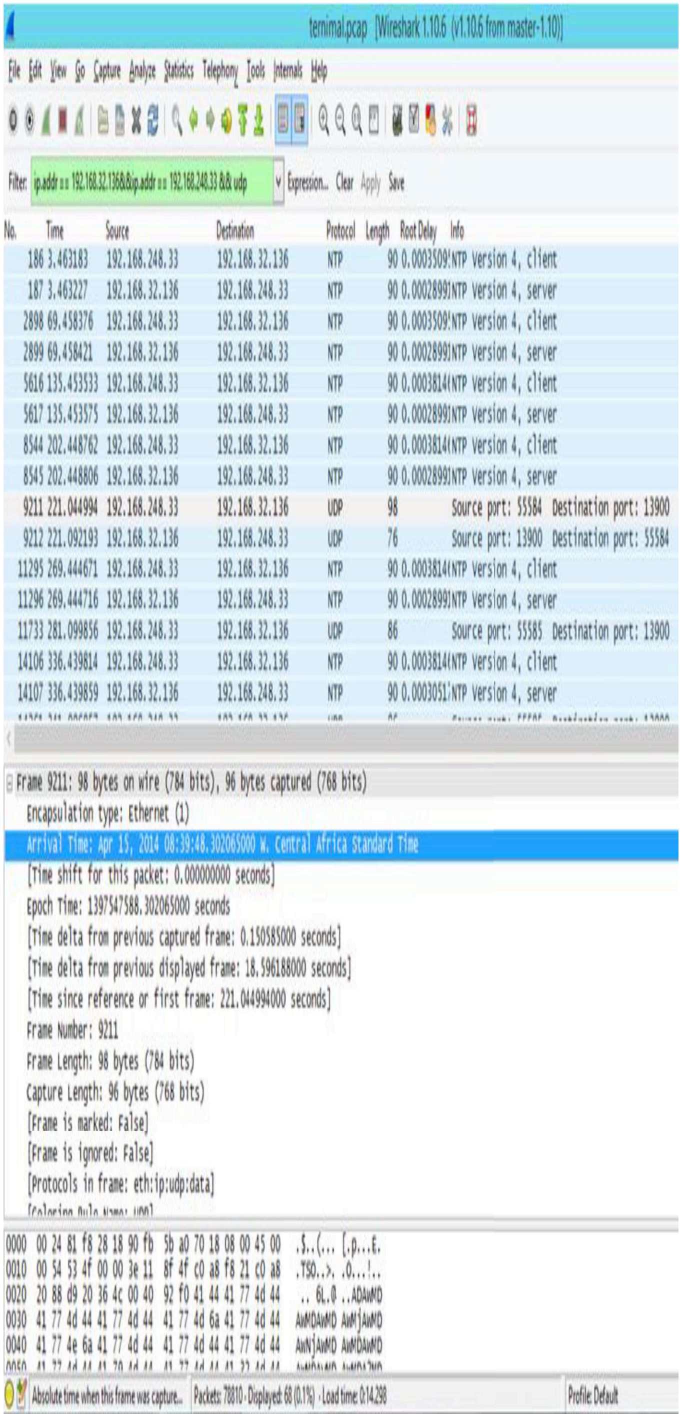

Figure 3. UDP Packets Captured at Terminal Interface

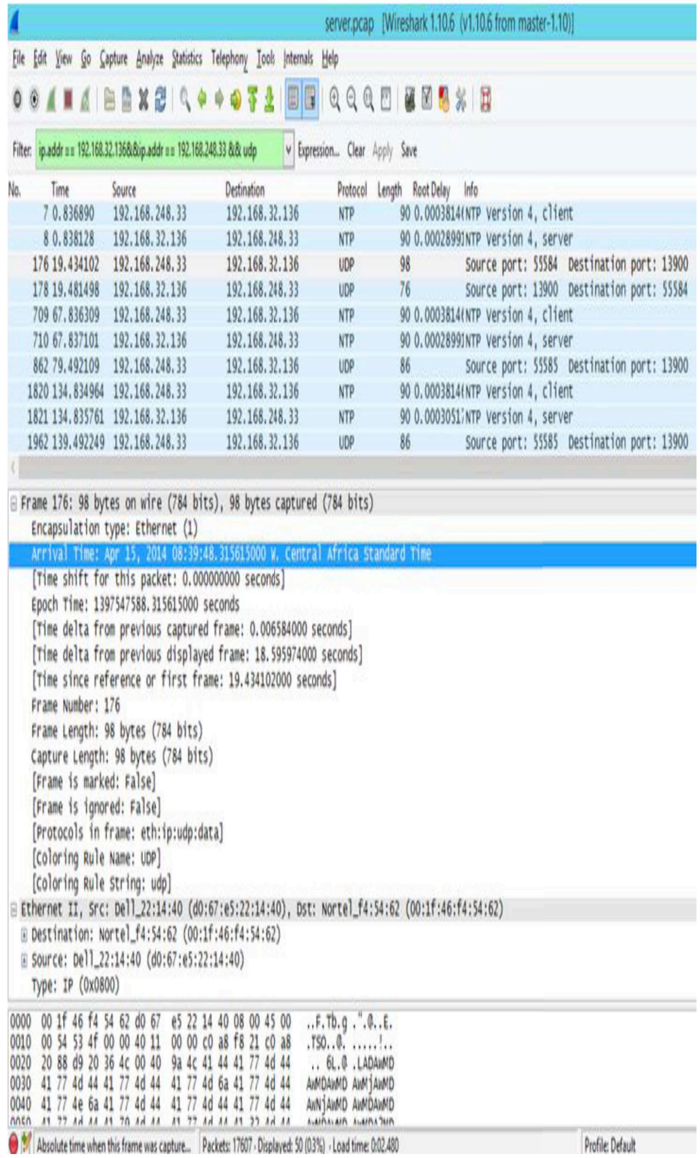

Figure 4. UDP Packets Captured at Server Interface

IV. LAB TEST RESULTS

Table 1.0 below show a summary of source and destination time recorded for the TAM packets as they travel from terminal to server over the Local Area Network over a 15 minute period. Average delay within this 15 minute was calculated as 0.037121429 seconds, similar results was obtained when the tests was run for hours. There was no Data loss within the test period as all the packets were accounted for after comparing the Wireshark capture for the server and terminal (fig. 3.0 and 4.0).

Table 1. SAMPLE TERMINAL AND SERVER TIME

	TERMINAL TIME	SERVER TIME	DELAY	AVERAGE DELAY
	Apr 15, 2014 08:40:48.356927000	Apr 15, 2014 08:40:48.373622000	0.016695	0.037121429
	Apr 15, 2014 08:41:48.353928000	Apr 15, 2014 08:41:48.373762000	0.019834	
	Apr 15, 2014 08:42:48.350136000	Apr 15, 2014 08:42:48.373123000	0.022987	
	Apr 15, 2014 08:43:48.346293000	Apr 15, 2014 08:43:48.372418000	0.026125	
	Apr 15, 2014 08:44:48.342461000	Apr 15, 2014 08:44:48.371738000	0.029277	
	Apr 15, 2014 08:45:48.338803000	Apr 15, 2014 08:45:48.371169000	0.032366	
	Apr 15, 2014 08:46:48.335983000	Apr 15, 2014 08:46:48.371539000	0.035556	
	Apr 15, 2014 08:47:48.333144000	Apr 15, 2014 08:47:48.371850000	0.038706	
	Apr 15, 2014 08:48:48.329359000	Apr 15, 2014 08:48:48.371158000	0.041799	
	Apr 15, 2014 08:49:48.325467000	Apr 15, 2014 08:49:48.370459000	0.044992	
	Apr 15, 2014 08:50:48.321811000	Apr 15, 2014 08:50:48.369935000	0.048124	
	Apr 15, 2014 08:51:48.319022000	Apr 15, 2014 08:51:48.370293000	0.051271	
	Apr 15, 2014 08:52:48.316218000	Apr 15, 2014 08:52:48.370624000	0.054406	
	Apr 15, 2014 08:53:48.313459000	Apr 15, 2014 08:53:48.371021000	0.057562	

To estimate the amount of data generated by the TAM system under ideal conditions in the lab, we have to isolate only packets related to the TAM system in the LAN traffic, they are;

- NTP packets used for time synchronisation, two are sent every minute; one from terminal to server, the other in the reverse direction. Each of the packets is 90 bytes in length.
- UDP packets for handshake, one in each direction. The frame from terminal to server is 98 bytes in length while the packet in the reverse direction is 76 bytes in length.
- The heartbeat packet is 86 bytes in length and is sent from terminal to server every 5 minutes
- The TAM packet is 86 bytes in length and is sent every minute.

NTP traffic per day = $90\times2\times60\times24$ = 259200 bytes

Handshake traffic = 76+98 = 174 bytes

TAM traffic = $86\times60\times24$ = 123840 bytes

Heartbeat traffic = $86\times12\times24$ = 24768 bytes

Total per day = 259200+174+123840+24768 =407982 bytes

Total per month = 407982×30 = 12239460 bytes $\approx$12.24 mb

V. FIELD TEST RESULTS

Table 2.0 is the log file generated from the test conducted in Kenya using Safaricom GSM network. Unlike the lab test, time was recorded to the nearest minute instead of to the second or fraction of second as was obtained in the lab, data loss was about 0.1% and amount of data generated was similar to the results obtained in the lab although will be less under real working conditions.

Table 2. SAMPLE LOG FILE FROM KENYA TEST

RECORD	STARTTIME	DURATION	CHANNEL	DECODERNUMBER	STATUS	ISONSHOW	SEQUENCE	R
1	16/11/2013 08:19	9	53	2101948296	1	1	0	ty
2	16/11/2013 08:19	9	-1	2101948296	1	0	2	ty
3	16/11/2013 08:19	7	-1	2101948296	1	0	3	ty
4	16/11/2013 08:19	18	-1	2101948296	1	0	4	ty
5	16/11/2013 08:19	46	-1	2101948296	1	0	5	ty
6	16/11/2013 08:20	9	-1	2101948296	1	0	6	ty
7	16/11/2013 08:20	11	-1	2101948296	1	0	7	ty
8	16/11/2013 08:20	4	-1	2101948296	1	0	8	ty
9	16/11/2013 08:20	112	-1	2101948296	1	0	9	ty
10	16/11/2013 08:22	8	43	2101948296	1	1	10	ty
11	16/11/2013 08:22	10	-1	2101948296	1	1	11	ty
12	16/11/2013 08:23	10	-1	2101948296	1	1	12	ty
13	16/11/2013 08:23	10	40	2101948296	1	1	13	ty
14	16/11/2013 08:23	10	74	2101948296	1	1	14	ty
15	16/11/2013 08:23	10	55	2101948296	1	1	15	ty
16	16/11/2013 08:23	10	-1	2101948296	1	1	16	ty
17	16/11/2013 08:23	7	56	2101948296	1	1	17	ty
18	16/11/2013 08:24	3	56	2101948296	1	1	18	ty
19	16/11/2013 08:24	10	57	2101948296	1	1	19	ty
20	16/11/2013 08:24	10	42	2101948296	1	1	20	ty
21	16/11/2013 08:24	10	73	2101948296	1	1	21	ty
22	16/11/2013 08:24	9	54	2101948296	1	1	22	ty
23	16/11/2013 08:24	10	72	2101948296	1	1	23	ty
24	16/11/2013 08:24	10	53	2101948296	1	1	24	ty
25	16/11/2013 08:25	10	41	2101948296	1	1	25	ty
26	16/11/2013 08:25	10	44	2101948296	1	1	26	ty
27	16/11/2013 08:25	10	39	2101948296	1	1	27	ty
28	16/11/2013 08:25	10	52	2101948296	1	1	28	ty

VI. CONCLUSION

The TAM consist of three parts namely, the terminal, the network, and server. The terminal and the server end exhibit expected behaviour , data loss over the GSM network is about 0.1% and is acceptable. As for delay, there are technical challenges to be overcome in order to be able to measure it accurately; the two major issues are time synchronisation and recording time in fractions of seconds on the terminal. As for the usability of the system, the issue of accurate measurement of delay is not very critical as TAM systems can tolerate a delay of up to 10 minutes or more. With the estimated data usage of about 12.24 mega bytes, data costs will be minimal and definitely much less than sending an engineer to collect physically every month.

REFERENCES

[1] A. R. M. Group, *Towards global guidelines for television audience measurement*: European Broadcasting Union, 1999.

[2] G. Mytton and UNICEF, *Handbook on radio and television audience research*: BBC World Service Training Trust, 1999.

[3] F. Alvarez, C. A. Martín, D. Alliez, P. T. Roc, P. Steckel, J. M. Menéndez, G. Cisneros, and S. T. Jones, "Audience measurement modeling for convergent broadcasting and IPTV networks," *Broadcasting, IEEE Transactions on,* vol. 55, pp. 502-515, 2009.

[4] D. Mukherjee, T. Chattopadhyay, S. Bhattacharya, A. Ghose, and P. Misra, "An architecture for real time television audience measurement," in *Computers & Informatics (ISCI), 2011 IEEE Symposium on*, 2011, pp. 611-616.