MULTIPLEXING OF TUTORIALS IN DISTANCE EDUCATION USING TV BROADCAST NETWORK

Arindan Saha[1], Aniruddha Sinha[1], Arpan Pal[1] and Anupam Basu[2]
[1]Innovation Lab, Tata Consultancy Services Ltd., Kolkata, India
[2]Indian Institute of Technology, Kharagpur, India

Keywords: Distance Education, Satellite Broadcast, Metadata in Analog Video, Spatial and Temporal Multiplexing.

Abstract: The demand of distance education in rural areas of developing countries like India is increasing due to unavailability of skilled teachers in rural India and limited or lack of infrastructural support. Moreover, in developing countries, the penetration of digital TV receivers is around 10% and remaining 90% uses analog TV receiver. Hence we propose a distance education solution which not only uses the exiting satellite broadcasting Television (TV) network but also maximizes the utilization of available bandwidth. In this paper we present a novel way of multiplexing of multiple tutorials simultaneously into one broadcast channel which is retrievable by the analog TV receiver. This multiplexing leads to a technical challenge of embedding multiple audio streams in a single analog channel which is overcome by treating them as a class of metadata.

1 INTRODUCTION

The poor quality of delivery of educational services in rural areas of the developing world (Akamai Technologies, 2010) can be attributed to the paucity of good teachers in these areas. As a consequence, the demand for distance education is on the rise in these areas.

Most of the existing distance education solutions are based on the broadband internet protocol (IP) connection (Basu, 2007). The average connection speed in India for example is 256 kbps (Akamai Technologies, 2010) and that is also mostly available in cities and urban areas. Although recently, wireless broadband connection is peaking up, the situation in rural areas remains pale due to the lack of infrastructure. Thus, the available solutions for distant learning (Franco, 2008), (Wattamwar, 2011), (Arger, 1990), (Basu, 2007) cannot be applied.

On the other hand, the local cable operators in developing countries like India occupy 90% of the market share in pay TV services (Murray, 2011). This indicates the dominance of analog client in households. There are a few solutions proposed (Vasantha, 2011), (Galajda, 2009) based on satellite connections, which either need costly specialized hardware setup or are less suitable for developing countries.

With the above motivation, we present an alternate approach for distance education solution based on the existing television broadcast network which uses a low cost Home Infotainment Platform (HIP) (Arpan, 2010) client box capable of taking analog video-audio as input and providing analog output to the TV.

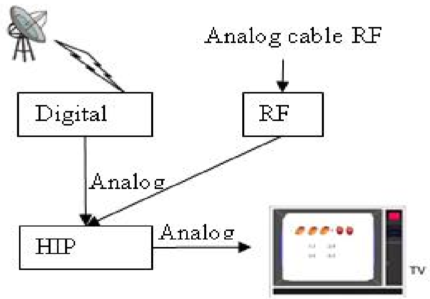

Figure 1: HIP based client configuration for distance education using TV network.

On the client end, the standard digital set-top box (STB) receives the satellite signal and extracts the analog video-audio (VA) as shown in Figure 1. The analog VA is then sent to the HIP client device which acts as pass-through for the normal TV channels and extracts the tutorial video, audio and metadata information for the tutorials channel. In the absence of the digital STB, the analog signal from RF cable operators are given to the HIP device via a

Saha A., Sinha A., Pal A. and Basu A..
MULTIPLEXING OF TUTORIALS IN DISTANCE EDUCATION USING TV BROADCAST NETWORK.
DOI: 10.5220/0003918003270330
In *Proceedings of the 4th International Conference on Computer Supported Education* (CSEDU-2012), pages 327-330
ISBN: 978-989-8565-06-8

RF demodulator. The desired tutorial is selected by the user which gets automatically recorded in HIP upon detection of the broadcast time for the same. The student can then consume the content in off-line mode.

In the country like India, it becomes a great challenge to support multiple states, each having their own curriculum and language, using a limited number of broadcast channels. Considering 6 classes per state, 6 subjects per class, 2 languages per tutorial and more than 22 states, it comes to 1584 tutorials; if each tutorial is of one hour then it requires 66 broadcast channels to broadcast 24 hours. This is an infeasible proposition. Hence there is a need to design a system which will reuse the standard broadcast infrastructure and standard receivers to support the above requirement within a few broadcast channels.

The novelty of the current paper lies in the architecture for the transmission of multiple tutorials (video, audio) simultaneously along with the metadata (questions and their associated answers) in a single TV channel using the existing infrastructure of digital broadcast. The robustness of the method of embedding metadata in analog video frame is analyzed in (Basu, 2012).

2 CREATION OF BROADCAST CONTENT

The video, audio and QA are multiplexed to create the broadcast content. The detail of the multiplexing is shown in Figure 2. A special video frame is multiplexed once in every 10 second along with the tutorial video. The special frame contains the tutorial information, QA of each tutorial and Electronic Program Guide (EPG) for the tutorials in the form of metadata (Basu, 2012). Due to the multiplexing of the tutorials, the video-audio related metadata are also inserted as new information in the special frame which is detailed in section 2.1. The encoded audio is also treated as metadata and embedded in normal analog video frame. The video of the tutorials are multiplexed in time and space in order to achieve compression. The multiplexed video is encoded using a standard video encoder (MPEG2) to generate the elementary streams.

The video of the tutorials are multiplexed in time and space in order to achieve compression. First level of compression can be achieved by reducing the resolution of each tutorial. Normal broadcaster will send SD (720x576) quality channels, but tutorial video does not need such high resolution video as they are of low motion in nature. The idea is to reduce the resolution to QVGA (320x240) so we can multiplex 4 channels in spatial domain as a 2x2 array. The resolution of each frame becomes 640x480, which is still less than the SD resolution. Now the remaining place in each frame is used for insertion of audio. The encoded audio is treated as metadata and is inserted as pixel data. The description of insertion is given in (Basu, 2012). Second level of compression can be achieved by reducing the frame rate to half of the normal. If we consider PAL system, the frame rate of each tutorial is reduce to 12.5 fps and this reduced frame rate gives us a chance to multiplex 2 channels in time domain. In Figure 2 the video encoded to QVGA resolution is encoded to 12.5 fps streams and finally two such streams multiplexed together to make final stream of 25 fps.

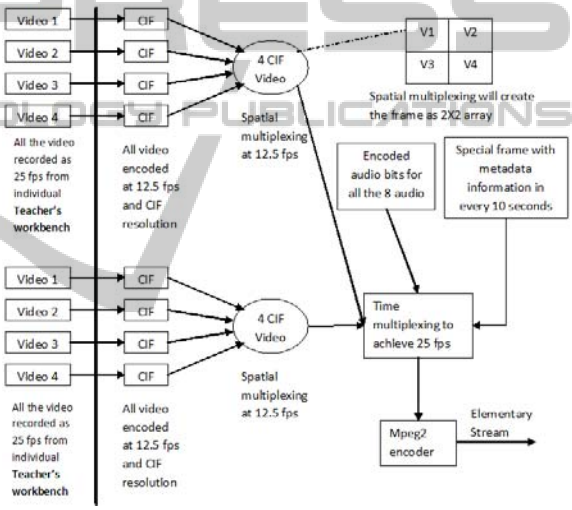

Figure 2: Content creation in broadcast end with spatial and temporal multiplexing.

So totally 4*2 = 8 tutorials can be simultaneously multiplexed within one channel as shown in Figure 2 and encoded with a standard video encoder. This multiplexed stream has one special frame in every 10 second.

Temporal multiplexing of spatially multiplexed tutorial sets is done within a Group of Pictures (GOP) as shown in Figure 3. The normal video frame in a GOP contains the pilot pattern, frame ID, audio and its language ID, encoded audio data and video data as shown in Figure 4. The tutorials are taken from MIT online courses on Linear Algebra by Professor W. Gilbert Strang.

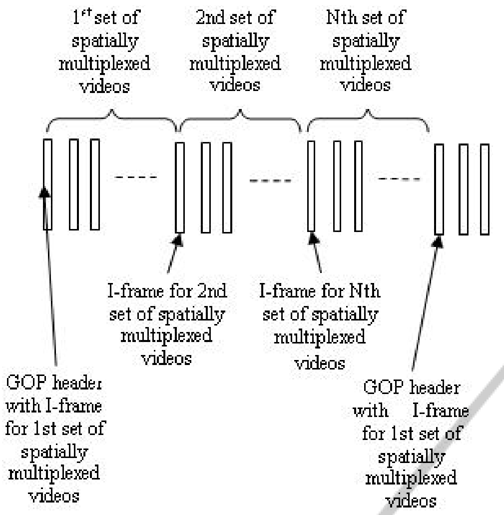

Figure 3: Temporal multiplexing of tutorials.

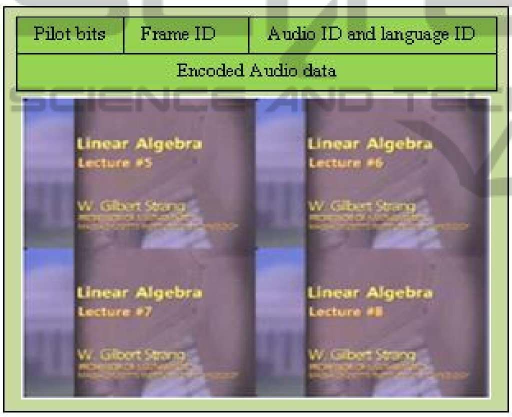

Figure 4: Layout of the normal video frame.

2.1 Video Audio related Metadata

The information required for extracting the multiplexed video and audio is present in the special frame in every 10 sec. The information encompassed the following:

- Number of tutorial in the current GOP (8 bits)
- For all the tutorials
  - Tutorial ID (32 bits)
  - Start offset in frame no. for video from special frame (8 bits)
  - Length of video in frame no. in the GOP (8 bits)
  - X-Y start co-ordinate of video (16+16 = 32 bits)
  - Width-height for video (16+16 = 32 bits)
  - Indication of end or not (1 bit) for the tutorial.
  - Fixed Marker bits (7 bits)
  - Start offset in frame no. for audio from special frame (8 bits)
- Pilot bit start location X, Y (16+16 = 32 bits). This is for video frames only.
- It is assumed that every line will start at X point in the video frame.
- Length of the data inserted in a line from point X (16 bits)

Thus assuming 8 tutorials are multiplexed, total required bits for all tutorials are (8 + (32+8+8+32+32+1+7+8)*8+48) = 1080 bits.

3 EXTRACTION OF TUTORIAL

A standard STB (e.g. TataSky) will able to receive and decode the channel and generate the analog video output. The HIP connected to the output of STB, receives the analog data in video input. The required tutorial is extracted by de-multiplexing the input video and recorded as selected by the user. The metadata is first extracted from the special frame in HIP box. This metadata provides the QA information.

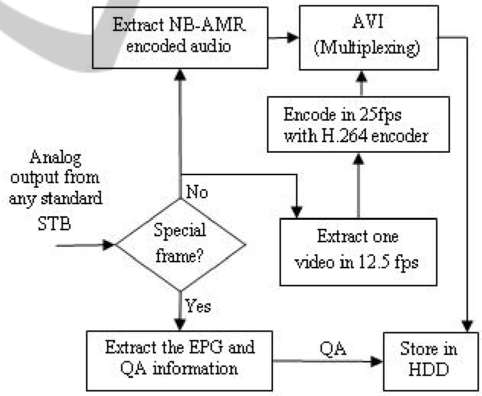

Figure 5: Content extraction in HIP client box for satellite broadcast.

The content extraction and recording process is done by the following steps and also as shown in Figure 5.

- Detects the special video frame.
- Extracts the EPG from the special video frame.
- Extracts the required tutorial video based on user selected input and the tutorial time information present in EPG.
- Extracts the QA.
- Extracts the NB-AMR encoded audio.
- Encodes the extracted video with H.264 encoder.

- Generates the multiplexed AVI file.

The audio and video extraction process from the normal video frames is shown in Figure 6 whose steps are given below:

- Synchronization to pilot symbols
- Extraction of frame ID
- Extraction of audio ID and language ID
- Extraction of encoded audio bits if the audio corresponds to the desired tutorial selected by the user
- Extraction of the video pixels if that corresponds to the desired tutorial selected by the user
- Encoding of the video to H.264

Encoded audio and video is multiplexed to store the same in local hard-disk for future consumption by the user.

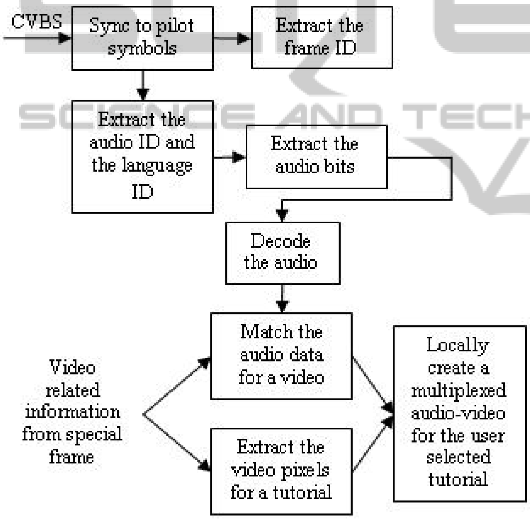

Figure 6: Extraction process of metadata, audio and video in normal video frame.

4 CONCLUSIONS

In this paper we propose multiplexing multiple tutorials in spatial and temporal domain to support lot more tutorials in a single TV channel to support distance education using a low cost client HIP box. The degree of multiplexing will depend on the cost of each tutorial to broadcast. To extract and play back the required tutorial it requires some metadata information and these metadata are inserted as part of the analog video frame. This metadata includes pilot pattern, tutorial information and QA. The encoded audio for multiple tutorials are also inserted as metadata into analog video frame. The acceptability of multiplexing multiple tutorials in spatial and temporal domain depends on the trade-off between bandwidth and video quality which needs to be further analyzed.

REFERENCES

Akamai Technologies, Q3 2010, Report on “State of the Internet”, http://www.akamai.com/stateoftheinternet/

Anupam Basu, Aniruddha Sinha, Arindam Saha, Arpan Pal, Jan 2012, “Novel Approach in Distance Education using Satellite Broadcast”, *3rd International Conference on e-Education, e-Business, e-Management and e-Learning*, IPEDR vol.27 (2012) IACSIT Press, Singapore

Arpan Pal, C. Bhaumik, M. Prashant, A. Ghose, June 2010, “Home Infotainment Platform”, *Proc. of International Conf. on Ubiquitous Computing and Multimedia Applications*, (UCMA2010), Miyazaki, Japan

B. B. De Franco and H. C. Oliveira, 2008: “A Communication Architecture For E-Learning And T-Learning Integration”, *IADIS International Conference*, pp.- 334-338, ISBN 978-972-8924-68-3

G. Arger. 1990: Distance education in the third world: Critical analysis on the promise and reality. Open Learning, 5(2):9–18

N. G.Vasantha Kumar; Mohanchur Sarkar; Vishal Agarwal; B. P. Chaniara; S. V. Mehta; V. S. Palsule; K. S. Dasgupta, 2011: “Digital Video Broadcast Return Channel via Satellite (DVB-RCS) Hub for Satellite Based ELearning, *International Journal of Multimedia & Its Applications*”, pp. 133-143, vol. 3, no. 1

P. Basu, A. H. Thamrin, S. Mikawa, K. Okawa, and J. Murai, 2007: Internet technologies and infrastructure for asia-wide distance education. *In Proceedings of the 2007 International Symposium on Applications and the Internet* (SAINT’07)

Pavol Galajda; Stanislav Marchevsky; Jn Gamec; Mria Gamcova; Slavomr Pillar, 2009: “Infrastructure For Packet Based E-Learning Services Provided Via Satellite”, *Acta Electrotechnica et Informatica*, pp.74-80,Vol. 9, No. 1

Simon Murray, 2011, "India digital TV forecasts", Digital TV Research http://www.ekmpowershop4.com/ekmps/shops/broadbandtv/india-digital-tv-forecasts-1-5-users-132-p.asp

Sujal Wattamwar, Tavleen Oberoi, Anubha Jindal, Hiranmay Ghosh, Kingshuk Chakravorty, 2011: "A Novel Framework for Distance Education using Asynchronous Interaction", a*ccepted in ACM MM MTDL*

Y-F. Ou, Z. Ma, and Y. Wang, January 2009: "A Novel Quality Metric for Compressed Video Considering both Frame Rate and Quantization Artifacts" in *Proc. of VPQM'09*, Scottsdale, AZ, USA

ITU-R Rec. BT.500-11, 2002, “Methodology for the subjective assessment of the quality of television pictures”