Volume 5, No. 7, September-October 2014

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

TECHNICAL NOTE

Available Online at www.ijarcs.info

Internet on Terrestrial Digital TV Networks: A Proposal for Space Allocation for Internet Data

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Abstract: Most countries over the world have been upgrading their Television broadcasting networks from analog to digital; this is because of the many advantages offered by the digital networks. Some of which include vast amount of information delivered by the digital TV system. It is in this concept that this paper proposes another achievable advantage that the digital terrestrial TV would offer to the consumers. Digital Terrestrial TV networks that also carry Internet data is the intention that is described in this paper. Given the vast networks that have already been implemented by service providers, users would find it very convenient just to plug the computers to the set-top boxes and access Internet. Consumers may find it very convenient to pay for the TV content and Internet usage separately. With several technologies like ATSC, DMB, DVB-T2 and ISDB-T already in existence, it is from this background that a concept to improve bandwidth, compression, source coding and line coding is suggested for maximum network exploitation.

Key Words: Digital Terrestrial TV (DTT), Advance Television System Committee (ATSC), Digital Multimedia Broadcasting (DMB), Digital Video Broadcasting- Terrestrial 2 (DVB-T2), Integrated Services Digital Broadcasting (ISDB), Orthogonal Frequency Division Multiplexing (OFDM), Digital Subscriber Line (DSL), Inverse Fourier Fast Fourier Transform (IFFT), Single Carrier (SC) and Multi Carrier (MC)

I. INTRODUCTION

Internet has become part of our daily lives and access to the Internet is nowadays not limited to computers connected to Digital Subscriber Line (DSL) networks but to almost every digital device. And the more devices we have that can connect to the Internet the better.

Current Digital TVs (DTVs) have the capability to connect to the Internet but only if one has a computer Internet connection. This means that, one would still pay separately for both Internet subscription and the DTV subscription. Digital Television broadcasting comes in many various platforms which include cable, satellite, Internet streaming and Terrestrial broadcasting. Terrestrial broadcasting is based on the existing terrestrial system of the analog TV and radio. With a simple antenna mounted on the roof top one can receive television signals [2]. The signal when properly modulated and coded can still carry enough information for TV and Internet content.

A survey of the World's dominant digital video broadcasting standards finds four major standards namely:

i. America: Advance Television System Committee (ATSC)
ii. China: Digital Multimedia Broadcasting(DMB)
iii. Europe: Digital Video Broadcasting- Terrestrial 2 (DVB-T2) and
iv. Japan: Integrated Services Digital Broadcasting (ISDB)

In this paper proposes a way by which the existing Digital Video Broadcasting- Terrestrial (DVB-T) bandwidth may be modified so that the Internet content may be allocated space is looked at.

Proper Conditional Access (CA) method is then used to allow a user access to either TV content, Internet content or both. The prototype of this system can be used to achieve the following objectives.

a. Determine if it is possible to implement the actual system
b. Have a test of several parameters [3]

With standards for satellite TV, cable TV, and DVB-T already existing in Europe, America and the rest of the world [3], to come up with this system, strict guideline has to be followed to make sure that the already squeezed DVB-T bandwidth is not interfered with. Mathematical models may be developed or the improvement of existing models may be done to ensure compatibility with existing systems. We analyse the bandwidth and how it can be shared by both the TV signal and Internet data. In comparison to the Japan's ISDB-T (Integrated Services Digital Broadcasting Terrestrial) which began in 2003 that was meant to carry audio, video and broadcast data (with XML used to view it), it is clear that the data carried on DVB-T is actually broadcast information meant for the TV viewer about the programming and not Internet data [4].

II. CURRENT TRENDS AND FADING

The current DVB-T standards can be grouped into two main categories as: Single Carrier (SC) and Multi Carrier (MC) or Orthogonal Frequency Division Multiplexing (OFDM). OFDM has proven to be a very successful technique in noisy environment with areas which are severely affected by multipath fading. OFDM divides the high frequency carrier into a group of subcarriers which are parallel to each other. Each sub-carrier is modulated by a lower rate binary signal and the orthogonally packed together using the Inverse Fourier Fast Fourier Transform (IFFT). Since line of sight (LOS) cannot be guaranteed in digital TV, precaution has to be taken to avoid Inter-Symbol Interference (ISI) and fading due to some selected frequencies. In systems that use OFDM where flat fading is experienced one tap equalization would be more appropriate.

One tap equalization is achieved by compensation from only one tap delay. In a discrete time system where the system output $y'(n)$ is given by $y'(n)=y(n)-y(n-1)$ such that n is the time index and $y(n-1)$ represent the delayed signal, and to form one tap delay we can subtract the previous tap from the current value.

The chaotic free space environment when used as the propagation medium as in the case of Digital terrestrial TV inserts loss which may cause flat fading, this is why it is appropriate to apply one tap equalization for the channel.

III. MODULATION AND SIGNALING SCHEME

Because of multipath fading, it requires complex adjustments for terrestrial data to be transmitted with minimal error. Since Orthogonal Frequency Division Multiplexing (OFDM) has been adopted for DVB great gains have been reached in terms of minimizing error. This paper recommends increasing the number of segments in ISDB-T in order to accommodate the Internet payload. For such technique to prove possible the segment size will have to be reduced. However this will affect the data rate, therefore a more efficient choice of digital modulation is chosen which may accommodate the increased data rate.

For most digital broadcasting platforms, 64-QAM is used. If the modulation scheme is raised up to 256-QAM then this means that extra parallel bits have been added these parallel bits can be used to carry the Internet data. Since Terrestrial digital TV is designed to lower data rates through compression both video and audio can be compression using lossy techniques while the Internet and broadcast data can be compression further using non-lossy techniques [4]. Figure 1 shows the basic system format.

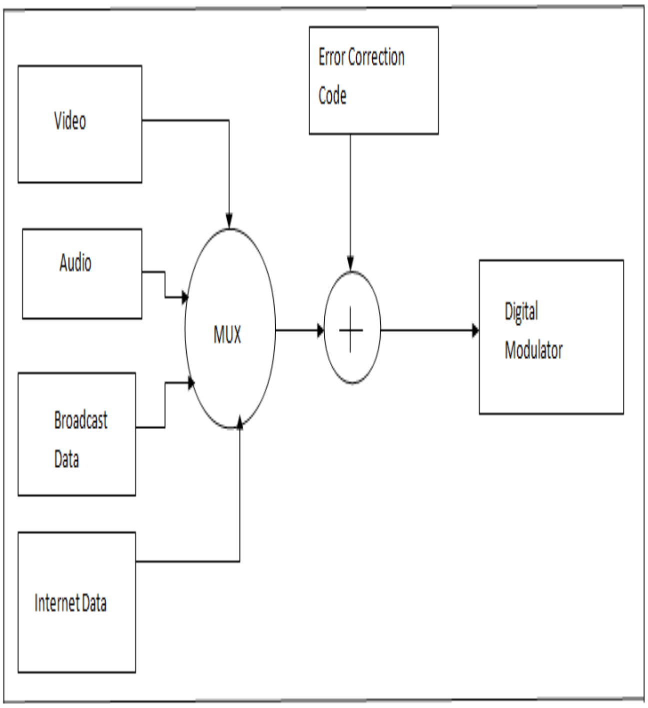

Figure. 1 Basic System Format

To provide better performance in a multi-fading environment, the system proposed should adopt a multicarrier OFDM. The ISDB-T adopts a 13 segment OFDM to accommodate terrestrial video and a single segment for mobile reception. Modulation techniques used for digital broadcasting include QPSK, 16-QAM, 32-QAM and even 64-QAM. QPSK is a common modulation technique employed in satellite communication due to its ruggedness with low carrier to noise ratio (C/N) [1]. The requirement here is that the bandwidth be sufficient enough to accommodate both audio, video, broadcast data and Internet data. It should be noted that the number of carriers used will not affect the band bandwidth however it is the modulation technique and the Guard Interval (GI) that determine the bandwidth that the broadcaster and the Internet Service Provider (ISP) may use.

Another way of accommodating more data especially that of the Internet is to use Multiple Physical Layer Pipes (MPLP) that can maintain standard modulation for broadcast video, audio and data but a different modulation for Internet data [5]. The author takes keen interest on ISBT as a platform for the intended outcome. The reason for this selection is that ISBT is a much established system as compared to the other three.

When there is need to increase the capacity of a DTTB channel the GI is taken in serious consideration because increasing it improves the system performance against multipath fading but reduces the system capacity.

$$Ts=\Delta+Tu$$

Where Δ = Guard Interval.
Tu=active carrier interval
Ts=the total system interval

A best case scenario will be, a very long GI with shortest guard fraction, this of course will achieve excellent multipath performance and a higher capacity in the channel. If a smaller guard interval is selected the DVB-T system would achieve a better transmission efficiency. The European DVB-T2 gives a better example with up to 6.65bits/Hz and 1/32 Guard Interval (GI). Currently the highest modulation scheme is 256-QAM used in DVB-T2 followed by 64-QAM adopted by both DTMB and ISDB-T. The use of 256-QAM has been very successful, but to accommodate independent Internet data, a high constellation modulation scheme has to be adopted. With Next Generation Broadcasting Technologies (NGBT) estimating the use of 1024 as a modulation scheme for DVB. Using a higher constellation in digital modulation like 2048-QAM is proven to offer better Bit Error Rate (BER) at the same time allows 11 bits/symbol. The simulation results shown in Figure 3. Illustrates the better performance of QAM at higher constellations Fig 3. Comparison of M-QAM Bit Error Rate in AWGN

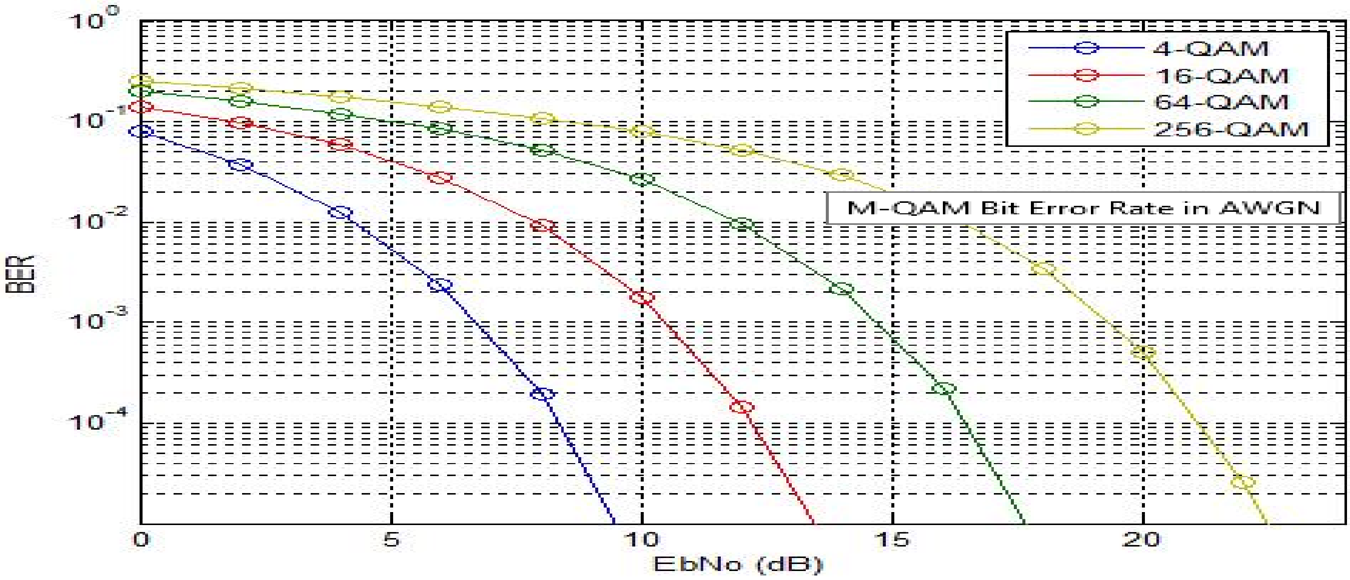

Figure 3. Comparison of M-QAM Bit Error Rate in AWGN

It should be noted however that the increase in the value of M in M-ary modulation scheme does not affect the number of OFDM carriers, but in a multipath fading environment like in DVB systems increase in carrier is recommended as this will limit the effect of echoes during transmission. The choice of inner coding is selected to allow more information bits per code. The challenge is that while more data is carried compromise is made on protection. The reduction in the number of codeword bits mean reduced redundancy. The ISDB-T has the lowest code rate at 7/8 so a recommendation is made for even lower code rate of up to and above 10/11.

In ISDB-T the transmission of TV signal consists of 13 successive OFDM segments blocks which are also known as segments, the bandwidth of each segment is equal to 1/14 of the TV broadcasting channel[6]. In a basic form ISDB-T is implemented as illustrated in Figure 2. Where is shows how Transmission Streams (TS) are re-multiplexed to form a main TS that is later channel coded.

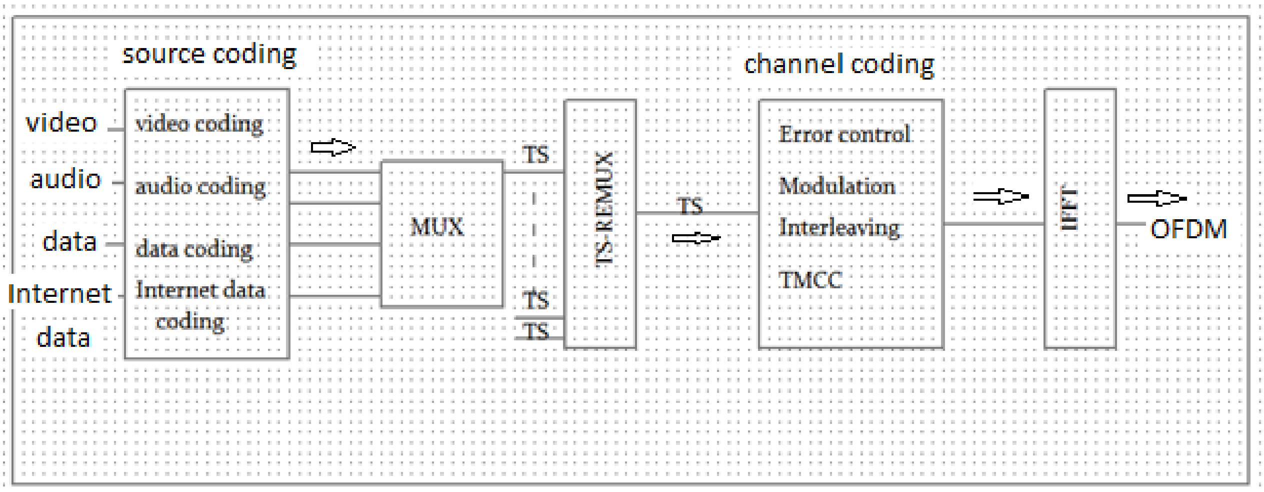

Figure.2 Improved ISDB-T DTTB system

The high demands for quality picture and audio put a lot of emphasis on the amount of data to be transmitted. Currently most DTTB use MPEG-4 and lately MPEG-H for video and MP3 quality audio. For the broadcast data and the Internet data it would be appropriate to use both lossless and lossy compression technique where possible. Optimized Register Transfer Logic (RTL) design and implementation of LZW algorithm for high bandwidth applications [7] would be a better choice for the Internet data proposed in this paper. The optimized RTL design provides a comparatively high throughput 1.42 Gbits/s, elevated throughput/slice value 151.8 Kbytes/s/slice and lower operational power requirements 333 mW. Over the ISO/IEC 23008-2 MPEG-H series of standards for video compression the High Efficiency Video Coding (HEVC) is a recommendation. Table 1. Shows the latest data rates for different DTTB standards [8].

Table 1. Latest data rates for DTTB.

Standard	Technology	Payload in an Approx. 8MHx channel
ATSC	Single carrier	6-27.5Mb/s
DVB-T2	Multicarrier OFDM	5.4-50.4Mb/s
ISDB-T	Segmented OFDM	4.9-31Mb/s
DTMB	Single carrier/Multicarrier OFDM	4.8-32.5Mb/s

IV. SET-TOP BOX CONFIGURATION AT HOME

The design of the set-top box is recommended to have an RJ45 port for a patch cord Personal Computer (PC) connection. The Figure 4.0 shows a home setup for the set-top for PC and TV. Terrestrial set-top boxes are meant to use the limited network broadcast network signal from a local service provider. Common set-top boxes are meant to receive and decode digital signal to for analog TV input. The set-top box proposed here will have two outputs for both TV and a computer capable of receiving data signals through the RJ45 network adapter.

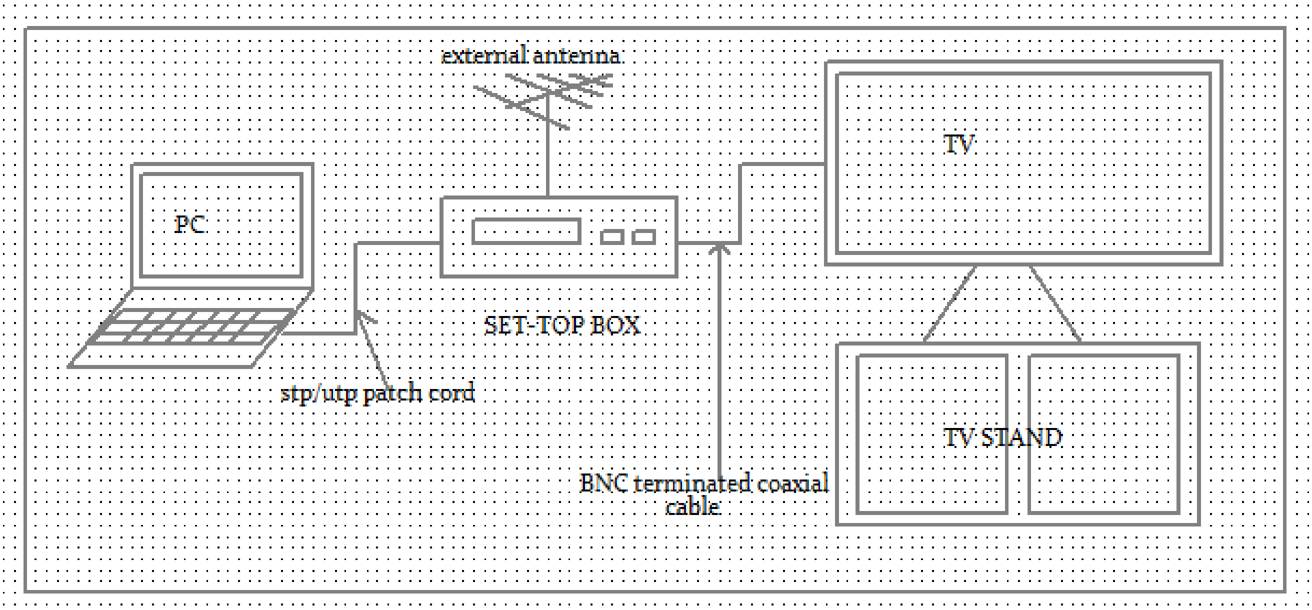

Figure 4.0 Set-top box home configuration

V. CONCLUSION

There are many techniques DVB-T that can be used to improve data capacity and all have different challenges that must be well researched and tested. This paper has only proposed one method among the many methods that DVB-T can be used to improve user experience by allowing the user to connect and access the Internet through there set-top boxes. Of course many Next Generations Networks will have even more advanced capabilities with even higher data capacities. This paper has not explored the detailed design issues involved but has given the starting point for further research. Interested researchers may still explore the very many stages that are not included in this paper. Such stages may include the layered design to comply with the existing IEEE, ETSI standards.

Other issues which may as well be considered in further research include the modification of the existing set-top boxes software for Conditional Access (CA).

VI. ACKNOWLEDGEMENT

I would like to appreciate the effort of my Co-author Mr. J. Abok for his work in reviewing this paper.

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