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Digital television in the delivery of multimedia education content

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Abstract

Broadband access has not reached all corners of South Africa, and yet the need to deliver multimedia education content to all schools in the country remains the same. Low-cost, appropriate technologies would enable schools in areas that would have otherwise been left out, to benefit from multimedia education content as well as those that have the infrastructure. This research is about taking advantage of South Africa's television (TV) digitalisation programme to deliver multimedia education content to all areas, to the benefit of the disadvantaged ones. Television transmission is planned to cover the whole of South Africa by 2015. The architecture for the delivery of multimedia education content includes the integration of an internet TV platform with messaging services, digitalisation of Department of Basic Education (DBE) learner material for distribution over the internet, a long distance TV white spaces technology, and a digital services node (DSN) for delivery of both interactive TV and education material. DSN is a digital television and broadband access device that connects to existing TV sets and delivers services such as digital basic education, digital video broadcasting of lessons, community internet television for neighbourhood discussion groups, digital terrestrial television (DTT) and community online gaming. This research proposes a similar access technology to asymmetric digital subscribe line (ADSL), where the uplink will be through a point-to-point TV whitespaces network or cellular technology and the downlink will be through digital video broadcasting (DVB). DVB is the standard that South Africa has selected for its TV digitalisation programme. Each DVB-T2 multiplex has the capacity to deliver 31Mbps, meaning for the same amount of bandwidth, much more audio, video and text can be sent over a digital channel than an analog channel. TV whitespaces is about using TV frequencies that are not in use for communication. The DTT is a set of standards for transmission of TV signals in digital form. A set-top box/adapter (STB) converts the signals used by the DTT to older models of TV receivers. ADSL is a type of DSL broadband communications technologies used for connecting to the internet. ADSL allows more data to be sent over existing copper telephone lines as opposed to traditional modem lines and provides continuously 'always on" connection. To extend DTT coverage a wireless mesh network is used in this architecture.

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Keywords: Intelligent set-top box (I-STB), digital terrestrial television, broadband internet access, digital video broadcasting, TV white spaces, digital services node, education, wireless mesh networks

1. Introduction

Broadband internet access, often shortened to 'broadband", is a high-rate connection to the internet. It is characterised by the ability to handle high volumes of data and high data rate content such as software downloads, video-on-demand, telephony and image-rich websites. Broadband penetration is widely recognised as a key enabler of socio-economic development, that is, economic growth, job creation, productivity and access to knowledge. South Africa has set a deadline of an analog switch–off to the end of 2013. The access to terrestrial TV will be through the digital network. The digital terrestrial television (DTT) is a new set of standards for transmission of TV signals in digital form. The set-top box / adapter (STB) converts the signals used by the DTT to older models of TV receivers. Intelligent STB (I-STB) enables broadband internet access in addition to the normal functionalities of an STB. The South African Department of Communications, through Sentech, intends to provide DTT infrastructure to cover 96% of the population by switch-off time. A well-considered intervention for South Africa is the development of a Digital Services Node (DSN) that directly addresses inclusion in the digital world. The initial focal point DSN should focus around services relating to basic education, that is, the DBE learning materials, digital video-rebroadcasting of lessons, community internet television for neighbourhood discussion groups, DTT and community online gaming. This research is on an architecture for the delivery of multimedia education content by taking advantage of a combination of technologies including digital television, TV whitespace network, digital video broadcasting , set-top boxes, wireless mesh network and a digital services node. TV white spaces are the frequencies that are not in use for communication by the incumbent at any point in time. South Africa has selected digital video broadcasting (DVB) as the standard for its digitalisation programme. To extend DTT to remote areas, a wireless mesh network is an additional component of this architecture. This paper first introduces technologies that are part of the architecture for digital television delivery of education content. Section 2 is the problem statement. Section 3 is on DVB and DTT, and section 4 is on TV white spaces. Sections 5 and 6 are on the set-top box and leveraging the set-top box for broadband delivery. Section 7 is on wireless mesh networks, while section 8 is on the DSN. Section 9 describes the architecture for delivery of education content through digital television. Section 10 is on the conclusion.

2. Problem statement

The aim of this research is to come up with the design of an architecture for the delivery of multimedia education content to both remote and urban areas. This architecture takes advantage of South Africa's television digitalisation programme which is set to be in full swing by the end of 2013 when analog switch-off occurs. The digitalisation programme will see a South African brand of low-cost appropriate technologies including TV white space management, digital video broadcasting, set-top boxes, wireless mesh networks and the digital services node being integrated into this architecture. The question that this research asks is:

"How can South Africa's digitalisation project and the related locally-developed low-cost appropriate technologies be harnessed to enable delivery of education content to the benefit of both rural remote and urban communities, in order to enable efficient and easy access to education resources and in the process improve the quality of education?"

The objectives of the research were:

- To conduct a literature review that leads to the identification of various technologies that could constitute the architecture
- To get firsthand information on the additional technologies of STB, DVB, TV white spaces, DSN, energy-efficient antennas, mobile education and broadband architectures that are already under research and development at the CSIR's Meraka Institute
- Design the architecture of the system to deliver education content.

3. Digital video broadcasting and digital terrestrial TV

Digital Video Broadcasting (DVB) was created in 1993 as an effort to create standards for the distribution of digital television via satellite, cable or direct terrestrial transmission. Before that TV broadcasting was based on MPEG2 transport, but now IP increasingly has influence in this domain. DVB issued standard proposals for satellite (DVB-S), cable (DVB-C) and terrestrial (DVB-T) channels in the late 1990s. To minimise power consumption for small hand-held devices with limited battery capacity such as personal digital assistants (PDAs) and mobile phones, the DVB-H added provisions for grouping packets of the same service together into short-time slices, which allows these devices to power-off receiving equipment for extended periods of time (Burklin, 2007). Driven by the demand for high quality mobile broadcasting services, digital video broadcasting – terrestrial (DVB-T) systems have been highlighted due to its high data rate. DVB-T systems operate in 2k or 8k mode, depending on the total number of subcarriers (Lee, 2012). According to the DVB-T standard, systems of this kind transmit compressed digital audio, video and other data in an MPEG transport stream, using coded orthogonal frequency-division multiplexing (CODFM or FDM) modulation.

DVB-T2 is offering a new way for broadcasting value-added services to end-users, such as High Definition (HD) TV and 3D TV. DVB-T2 brings an increased transfer capacity of 50% and a new flexibility in services broadcasting in contrast with the first generation DVB-T standard. DVB-T2 allows a high robustness against multipath propagation. DVB-T2 uses a coded-orthogonal frequency division multiplexing (CODFM) multi-career modulation in a similar way to DVB-T (Ksentini, 2012). It offers a second-generation standard for digital terrestrial television broadcasting.

The current global trend towards a switch from the traditional analog television broadcast to digital terrestrial television (DTT) (DTT project, 2012) leads to opportunities for providing such broadband access to remote, rural, and under-served areas. These opportunities are based on the upcoming availability of frequency spectrum with good signal propagation characteristics, existing availability of modern efficient technologies and governmental initiatives for converting from analog to digital television.

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The standards used in DTT are based on advanced modulation and coding techniques which require much less frequency spectrum to deliver picture quality superior to that of analog television. This leads to some spectrum previously used by the analog television to become available for other uses. This phenomenon is commonly referred to as Digital Dividend. The spectrum used by analog television is in the VHF and UHF frequency bands which provide excellent signal propagation characteristics, permitting to send signals further whilst using less power as compared to many existing telecommunication technologies such as WiFi/802.11 or existing WiMAX equipment. For a fixed transmitter power level, fixed antenna gain and fixed attenuation of the signal in the air (e.g. to satisfy a certain sensitivity threshold of a receiving device), increasing the frequency translates into a proportional decrease in communication distance.

Digital TV (DTV) broadcasting consists of multiple digital processing steps. The delay that each processing step introduces accumulates and can be largely compared to analog transmission. Some of the sources that cause delay in digital TV are (Mekuria, 2012):

- Encoding and capturing introduces delays at studio/broadcast source
- A conversion of digital images format, e.g. to adapt to screen size
- Modulation, coding and propagation, e.g., when a satellite signal is used, a delay of 120ms occurs
- Decoding, buffering and rendering also introduce a delay based on the digital TV and set-top box hardware.

4. TV white spaces

The inability to obtain frequency spectrum for meeting the surge in demand for wireless solutions has been a worldwide problem. The proliferation of wireless devices has led to an impending spectrum crisis. To provide more spectrum, spectrum regulators worldwide are exploring techniques to reuse unoccupied TV channels (white spaces) for data communications (Nychis, 2011). Wireless devices can either sense the spectrum or consult with a geo-location database or learn about available TV channels it can use for wireless communication (Chandra, 2012). The recent advancement in TV white space which uses the frequency spectrum opportunistically when the incumbent users are not utilising these spectrums, sheds some light into the opportunities of reusing the underutilised spectrums (Oh, 2011). TV whitespace is the unused frequency on the TV band (Masonta, 2012). These frequency bands are among the best possible spectrum available for future wireless services due to their better propagation characteristics. The advantage of using TV white spaces is the large range it could cover. Depending on the TV band frequency that is used and the propagation environment, the range advantage could be in the order of 3 to 40 times. In addition, lower frequencies also could penetrate walls easily. Due to its range and penetration abilities, direct point-to-multipoint topology is possible.

Traditionally, TV frequencies are classified as very high frequency (VHF) and ultra-high frequency (UHF). VHF is 120 to <400 MHz, while UHF is from 400MHz – 900MHz. TV whitespace lies between UHF and VHF and is the unused frequencies that are normally licenced to broadcasters. The TV whitespace is currently underutilised. The television stations already use TV whitespace to broadcast education content. The cellular networks are eyeing TV whitespace due to its good propagation characteristics. The whitespace frequencies penetrate through walls, buildings, trees and travel further than current cellular frequencies. The added advantage is that currently most regulators, e.g., FCC in America and OFCOM in the UK, have decided to allow communication through TV whitespaces with licence exemption. Many organisations can now transmit without a licence which is ordinarily very expensive to acquire and maintain. The TV broadcasters on the other hand are resisting handing over TV whitespaces. After digital migration, South Africa will release more TV white spaces. This is because analog TV takes up more bandwidth as opposed to digital TV transmission. Therefore moving to digital transmission will release more bandwidth.

An example of TV whitespace usage is at the Microsoft campus in Redmond, WA, USA. Campus shuttles have internet connectivity over TV white band spaces. A whitespace radio in a shuttle communicates with two base stations deployed on buildings on campus. Inside the shuttle the white space connection to WiFi is bridged so that a laptop that does not have an integrated white space radio can connect to the internet using WiFi within the shuttle and white spaces between the shuttle and base stations (Chandra, 2011).

5. Set-top-box

The switch from analog to digital television places certain demands on an end user. A typical traditional analog TV set is incompatible with the new digital signals. In order to avoid the need to replace the whole TV, a set-top box (STB) is introduced (Set-top box, 2012). An STB receives the digital signal from an antenna and translates it into a format compatible with the analog TV. Such an intermediate measure is a cost-effective way to introduce digital television and to free up valuable frequency spectrum, with a country-wide scale. The STB category encompasses devices that range from MP3 jukeboxes, digital satellite receivers to digital video receivers.

A set-top box (STB) is necessary for television viewers who wish to use their current analog TV sets to receive digital broadcasts. In the digital television (DTV) realm an STB contains an operating system (OS), random access memory (RAM) and an MPEG decoder chip, and more chips for audio-decoding and processing. Digital television STBs are used for satellite, cable and terrestrial DTV services. In the internet realm, an STB is a specialised computer that can “talk” to the internet – that is, it contains a web browser and TCP/IP. The service to which the STB is attached may be through a telephone line as, for example, with Web TV or through a cable TV company.

Sentech, the organisation responsible for rolling out the digital broadcasting network in South Africa, has now rolled out the DVB-T2 network to 61% of the population and supports local production of DVB-T2 STBs. The DVB-T2 transmission standard with MPEG-4 compression was adopted by SADC for DTT. There are 3 DTT multiplexes for South Africa. The first is used for public broadcasting and includes the SABC and the Eastern Cape community Trinity Broadcast network. The second is the commercial free-to-air broadcasts including eTV. The third multiplexer is reserved for Pay TV operator MNet.

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6. Leveraging the set-top box for delivering broadband

The availability of internet access and interactivity through DTT requires the availability of two information/logical channels. One channel, called the broadcast channel, is required to send the information from a website or TV station to a user. The other channel, called a return channel, is required to transmit the information from a user towards the TV station and/or website. The return channel is necessary for TV reception.
The set-top box (STB) is for realising the co-existence of a specific return channel technology with DTT. The realisation of a down-link can be done in any of the following ways:

- Using a separate transmitter and antenna for the broadcast and return channels, or
- By mixing the digital TV signals with the internet signals and using a common antennae, or
- By embedding the internet signalling information into the digital TV signal.

Using separate transmitters and antennas to provide internet access is easier to implement as the DTT equipment and internet access equipment do not depend on each other, and readily available mass-produced equipment for internet access can be used. The only restriction that would need to apply is to have DTT and internet signals separated, e.g. at sufficiently different frequencies, as to be able to avoid mutual interference. Possible implementation of this scenario is usage of WiMax, iBurst, and 3G, HSPA and LTE technologies. In practice however, these technologies are not well-suited for long-distance communications comparable to the 70km reach of a typical TV station. The main reason is that WiMax, iBurst, 3G, etc, use high frequencies.

Using a common antenna for internet access and DTT offers cost savings, especially on the end user/consumer side. These savings stem from eliminating the cost of an additional antenna, cable and installation. The technical challenge lies in the need to have a separation between the DTT and the internet signals stronger than in the case of using the independent antennas. In addition, as the two signals have to be obtained from the same antenna/cable, the signal strength using this approach will always be at least 3dB lower than in the previous case.

The signalling necessary for broadband internet access could also be embedded directly into the DTT signals. This approach can potentially lower the cost of equipment, but requires designing compatible equipment, also needing a substantial investment in research and development.

7. Wireless mesh networks

A mesh is connectivity between two or more nodes in a network. Mesh nodes are small radio transmitters that function in the same way as a wireless router (Mesh networking, 2012) and (HowStuffWorks, 2012). Nodes use the common WiFi standards known as 802.11a, b and g to communicate wirelessly with other users. Nodes are programmed with software that tells them how to interact within the larger network. Information travels across the network from point A to point B by hopping wirelessly from one mesh node to the next. The node automatically chooses the quickest and safest path in a process known as dynamic routing. Between the source and destination nodes there is more than one

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relay. Characteristics of mesh networks that distinguish them from the linear chain are multi-routing capability, multi-hopping and multi-relays. On the software end the mesh network has to self-configure, self-heal and self-organise. Self configuration is finding the route automatically without human intervention by locating the route, neighbour, topology and connectivity. It should set its own parameters. Self-healing means that if one node dies due to battery failure, theft, lightning strike, etc, the network picks up by using other routes. Self-organising means that if any new nodes are added to the network, the network should organise and recognise their IP addresses. This is about scalability issues. Unlike base stations in the cellular networks which are not automatically configured by other base stations but have to be done manually, mesh networks self-organise. Therefore mesh networks are software-driven rather that hardware-driven. The biggest advantage of wireless mesh networks, as opposed to wireless or fixed networks, is that they are truly wireless. In a wireless mesh network, only one node needs to be physically wired to a network connection like a DSL internet modem. That one wired node then shares its internet connection wirelessly with all other nodes in its vicinity. Therefore wireless mesh networks are ideal in connecting remote areas. The more the nodes the further the connection spreads.

8. Digital services node

The Digital Services Node (DSN) is digital television and broadband access device that connects to existing television sets and delivers digital services such as digital basic education, digital video rebroadcasting of lessons, community internet television for neighbourhood discussion groups, digital terrestrial television (DVB-T2) and community online gaming. It aims to address youth inclusion in the digital world by bringing digital services to their living rooms. The development of DSN exploits the community wireless mesh networks, IPv6 development, energy-efficient wireless mesh protocols and internet video streaming. The key features of DSN are:

- Utilise the TV white spaces to enable broadband access through the node
- Incorporate wireless mesh networking to provide a mechanism to extend TV coverage and access to broadband beyond the reach of DTT coverage through wireless mesh
- Broadcast video content over bandwidth-constrained networks such as the wireless mesh network.

9. An architecture for delivery of education content

Armed with I-STB, a child in a remote school can access education material at the click of a remote control button for the current TV (Figure 1). I-STB supports DVB-T2 digital receiving and in addition can access multimedia education material through a dedicated channel. The text can be provided in eBook format and read using the eBook reader that comes standard with I-STB. The audio and video content can be accessed through the media player that also comes standard with I–STB. I-STB can provide full access to the internet through a pay service of the user’s choice, either through the built-down converted Wi-Fi or through other technologies that can be plugged in via a USB port.

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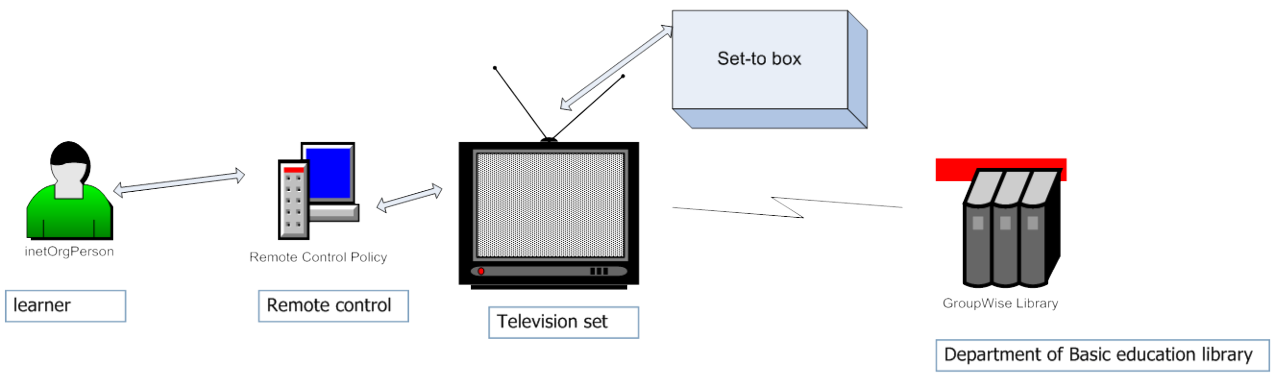
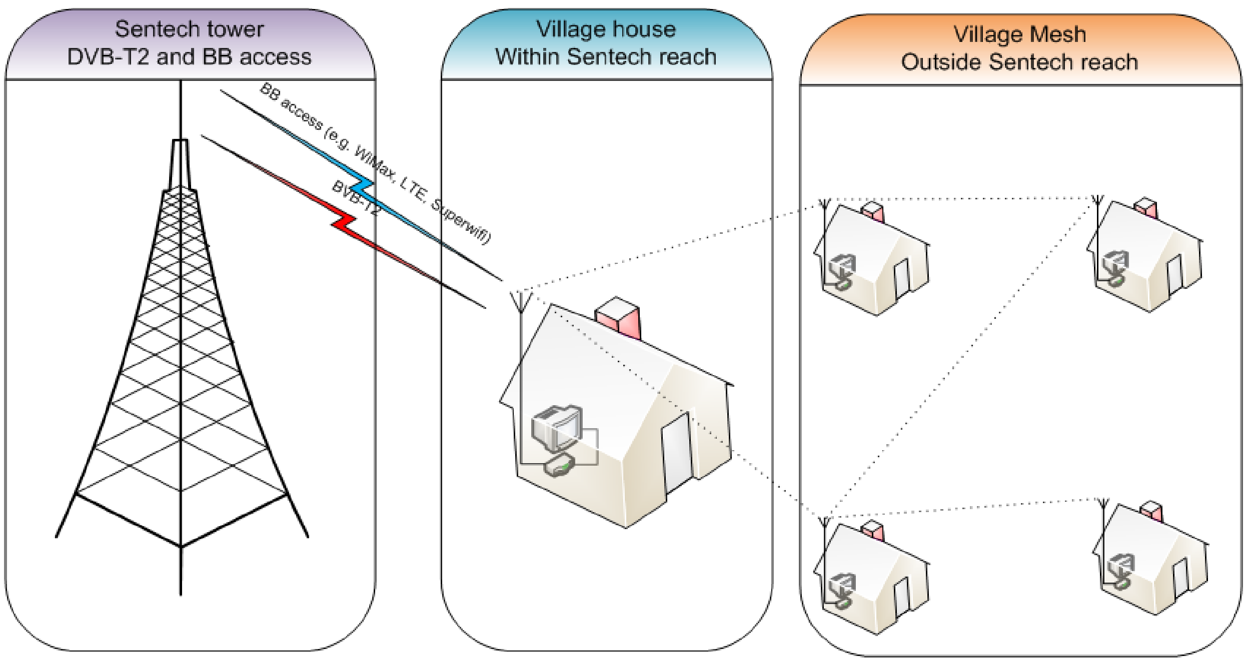
Figure 1: Delivery of education content



The hardware for the STB is based on a PC platform and requires PC audio and video output to be mixed/ switched with the digital TV output to allow the user to seamlessly control selections via remote control (i.e. switching between TV output and PC video output). The return path should use the digital dividend as well as existing white spaces. The spectrum in these bands is good for communications as the coverage is much wider than the bands above the 2GHz that are used for wireless data communication. An additional feature is the use of wireless mesh on the white spaces to reach homes that are outside the DTT coverage (Figure 2). The TV broadcast is encoded at the gateway node and streamed over the mesh to the nodes that are out of range.

Figure 2: Extending DTT coverage using wireless mesh



The main challenge is in the need to have the user interface compatible with a low resolution, low quality TV set possessed by many in South Africa, and the difficulty of capturing information without a keyboard (i.e. by using a remote control simulating a mouse). These challenges could be addressed by taking advantage of the existing

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software designed for smart phones, as these phones usually offer a limited screen resolution and cell-phone type of keyboard.

Using digital dividends and white space for the return path will provide an opportunity for using the same antennae as for the return path and the TV. The white space/digital dividend transmitter can be set up on the same mast using non-overlapping channels. An option is to design a new antennae which will need to support beam-steering or switching, ideally with two independent beams (one for TV and one for data) to counteract possible interference around TV stations when using TV communication as well.

The operating system (OS) is Linux-based to reduce the cost of licencing. The OS should support GStreamer (MPlayer) to add low-rate adaptive streaming of live video.

In view of the costs associated with national scale implementation, the best option is using the same antenna for both DTT and internet signals. This eliminates the cost of additional antennas, cables and installation. The two technologies considered are DVB/RCT and up/down converted WiFi. The digital video broadcasting – return channel terrestrial (DVB-RCT) is a standard for creating the return channel (up-link) compatible with digital video broadcasting (DVB). The technology services cells of a radius up to 65kilometres and permits multiple users.

10. Conclusions

This paper looks at the analog television as an alternative mode of education content for South Africa. The majority of South African households have access to TV sets. Therefore advantage should be taken of using this device to access education content especially so by the less privileged members of society. By making broadband accessible through TV whitespaces, education material can be transferred from a DBE digital library to a television set for access by the learner. The mode of interaction with the television is via a remote control. TV whitespace will soon be in abundance in South Africa, as a result of the move from analog to digital TV. The total architecture described in this paper is from combination low-cost appropriate technologies that were developed in South Africa.

11. References

Burklin, H., Scafer, R., Westerkamp, D. 2007. DVB: From broadcasting to IP delivery, SIGCOMM computer communication review, 37(1): 65-67, 2007.

Chandra, R. 2012. White space networking beyond TV bands, In: Proceedings of the 7th ACM International Workshop on Wireless Network Testbeds, Experimentation, Evaluation and Characterisation WiNTECH 2012.

Chandra, R., Moscibroda, T., Bahl, P., Murty, R., Nychis, G., Wang, X. 2011. A campus-wide testbed over TV whitespaces, SIGMOBILE mobile computing and communications review, 15(3).

DTT Project. (n.d.) Available www.ipo.org.za/Reports/DigitalMigration/SABC_DTT_FAQ.pdf, accessed 21 August 2012.

HowStuffWorks (n.d.) How wireless mesh networks work", Available http://computer.howstuffworks.com/how-wireless-mesh-networks-work.htm, accessed 21 August 2012.

Ksentini, A., Hadjaj-Aoul, Y. 2012. DVB-T2 simulation model for OPNET Poster abstraction, In:Proceedings of the 5th international ICST Conference on simulation tools and techniques.

Lee, Y., Park, J.I., Yoon, S. 2012 Pilot-assisted IFO estimation schemes for DVB-T systems, In: Proceedings of the 6th International Conference on Ubiquitous Information management and Communications ICUIMC'12, Article No. 121.

Mesh networking, Available http://en.wikipedia.org/Mesh_networking, accessed 21 August 2012.

Masonta, m. T., Johnson, D., Mzyece, M. 2011. The white space opportunity in Southern Africa: measurements with Meraka Cognitive Radio platform, AFRICOMM 2011, LNICST 92: 64-73.

Mekuria, R., Cesar, P., Bulterman, D. 2012. Digital TV: the effect of delay when watching TV, In:Proceedings of the 10th European conference on interactive TV and video EuroiTV'12: 72-74.

Nychis, G., Chandra, R., Moscibroda, T., Tashev, I., Steenkiste, P. 2011. Reclaiming the white spaces: spectrum efficient co-existence with primary users, In: Proceedings of the 7th conference on emerging networking experiments and technologies CoNEXT'2011.

Oh, S.W., Chin, F., Kerk, S.G. 2011. Proceedings of the 4th International Conference on Cognitive Radio and Advanced Spectrum Management CogART 2011, Barcelona, Spain.

Set-to box. (n.d.) Available http://en.wikipedia.org/wiki/Set-top_box, accessed 21 August 2012.

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