ON APPLICATIONS OF TELEVISION WHITE SPACE SYSTEMS

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Abstract: *Television white space (TVWS) systems have great potential for deployment in specific situations. So far, systems operating in TVWS band have been described from standardisation aspects and performance improvements. There is evident lack of literature dealing with deployment aspects. In this paper design of TVWS system in emergency situations is described and an example in the case of disease is given. It can be concluded that with the small investment, in a short period of time TVWS systems could be deployed in specific situations, providing services that are competitive to Wi-Fi and cellular network services.*

Key words: *Television white space, Network design, Emergency situations*

1. Introduction

Introduction of new technology is usually associated with commercial deployment. There is always a question if a new technology could be widely adopted by the industry and users. In general, deployment in critical and rather specific missions is not analysed. TVWS band has significant potential to be used in emergency situations as well as frequency band for alternative technologies to provide telecommunication services to underserved population.

There are several technologies that could be used in TVWS band for different applications. Next to proprietary technologies, there are several IEEE standards that are providing standardisation basics for outdoor systems [1-3], as well as for indoor applications [4]. Nevertheless, these standards and available literature is more focused on standardisation issues and less on deployment potentials of these technologies. Recently, there was interest in investigating options for using TVWS for cellular networks [5] and extension of cellular networks transmission in the unlicensed bands and in licensed ones as a secondary user [6]. Nevertheless, potential deployment of TVWS system in specific situations has not been analysed in literature.

The paper is organised as follows. In Heading 1, we briefly discuss current research related to TVWS systems deployment. Heading 2 describes potential deployment in emergency scenario. Example of network deployment in the case of a need to quickly provide communication services is given. Heading 3 provides concluding remarks.

2. TVWS Systems Deployment in Emergency Situations

It is crucial to have proper communications among all participants in crisis situations. In situations like natural disasters, or in digital battlefield, or in case of global health threats, any information has to be timely distributed in order to allow all teams to coordinate and to focus on the real and existing problem in the field. Focus on issues that are not critical or even on wrongly understood problems could lead to damage that could be hardly compensated.

Communication systems for the emergency situations have been present for years. Main characteristic of such system was that they were all wireless systems. Wireless links are relatively easy and fast to deploy thus service could be started rather fast. Major drawbacks of such systems were available frequency bands for the operation and technologies used. Previously used wireless systems in emergency situations were based mostly in 11GHz frequency band or in lower frequencies, that were intended for microwave (MW) systems.

Major improvement was introduction of WiMAX as available system. It is standardised technology [7] operating at 3.5GHz, thus providing better propagation conditions and quality of service (QoS) for voice and data transmission. Fixed WiMAX systems were able to provide throughput on the order of up to 18Mb/s on physical (PHY) layer in 3.5MHz FDD channel or in 7MHz TDD channel. Such throughput per sector or base station (BTS) was rather satisfactory at the time and still could be treated as more than good enough, but the price of terminals and lack of production in these days makes such systems slowly outdated.

Satellite based networks, like very small aperture terminals (VSAT) networks, provide smaller throughput comparing to WiMAX and also cost much more. Although satellite solutions are not expensive to deploy and could be deployed fast because they require only the installation of terminals, price per unit of throughput is high comparing to any other technology. Also, maximal available throughput is under the performance of WiMAX systems so this might not be enough to satisfy all end user requirements.

TVWS networks operate at ultra high frequencies (UHF), starting from 470MHz up to 698MHz, but could operate alternatively at very high frequencies (VHF). These frequency bands allow much better signal propagation, thus longer ranges and transmission without line of site (LoS). In the same time, available throughput is from 2 to 16Mb/s on IP layer and up to 20Mb/s on a physical level [8].

In critical situations, like natural disasters, UHF band has enough of unoccupied channels that could be used for alternative technologies like TVWS. Also, as per standard, TVWS systems could operate as secondary users of spectrum and thus coexist with TV transmitting equipment as secondary users. Finally, standards [1-3] define TVWS systems as IP based systems thus making them transparent for higher layer services.

Global diseases like ebola require fast response. It also requires presence in the field due to need to educate population in prevention of disease as well as to provide care for those who are already ill. Most efficient solution is to establish a number of small, temporary hospitals to provide medical care. Creating large number of hospitals would require very large number of highly educated medical staff. Since large number of such staff is not available in short period of time, usual strategy is to have medical technicians in the hospitals and smaller number of specialist who can provide advice from case to

case located on one location in the country or in many locations outside the country. Medical staff in micro hospitals would report to specialist (uploading appropriate documentation) and organise conference calls while the specialists would reply with appropriate diagnosis or with some other kind of help. Obviously, since micro hospitals are temporary solutions, it is necessary to develop appropriate telecommunications infrastructure that will accompany them. This infrastructure needs to be planned and deployed rather fast, as soon as the location of a micro hospital is known.

TVWS network could be deployed as fixed wireless access (FWA) system that could provide necessary telecommunications infrastructure. Freetown, the capital of Sierra Leone is an example of a city that is fighting with contagious disease and where a number of micro hospitals need to be established in order to fight disease. Freetown is the city on the shore and it is basically made of several smaller cities. In the back, high mountains are present, Fig.1.

Figure 1. *Geographic location of Freetown*.

Highest points of these mountains go up to 500m above sea level while the most of the city is very close to the sea level. For the coverage of Freetown in Sierra Leone, best solution is to deploy TVWS BTSs that would be located at the existing cellular network towers or on the new towers that would be located on the hills just above the city. Since the locations of micro hospitals are not initially known and if the new ones will be needed, coverage of the whole city is planned. Because of that, 8 locations have been selected. African continent is characterised by the small number of terrestrial TV channels so finding available TVWS spectrum is not an issue. Again, dynamic spectrum access is inherent part of TVWS systems so possibility of coexistence with TV signals is also viable solution. Nevertheless, system has been planned with 3 8MHz wide TV channels and additional 2 channels are planned to be kept in reserve for the potential future expansion of the system. Omnidirectional antennae with 5.2dBi, have been used as easier to deploy and with broader coverage.

In order to perform coverage analysis, digital terrain model (DTM) of resolution better than 50m×50m in horizontal plane had been used, with approximate resolution in height of 12m. Clutter database had been used to improve precision of coverage analysis. Clutter database included 10 types of clutter, starting from rural, over hydro to industrial and urban clutter categories, Fig.2.

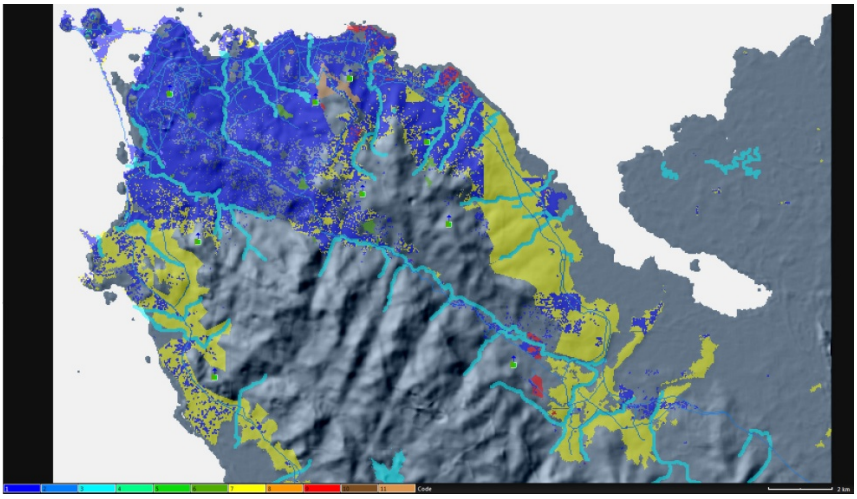

Figure 2. *Freetown DTM and clutter data.*

Initial coverage analysis has been performed using ITU recommendation P.1546. It can be concluded that the coverage of the city has been achieved on satisfactory level, Fig.3. Coverage values were presented for the values above -94dBm which is the minimum required value for BPSK.

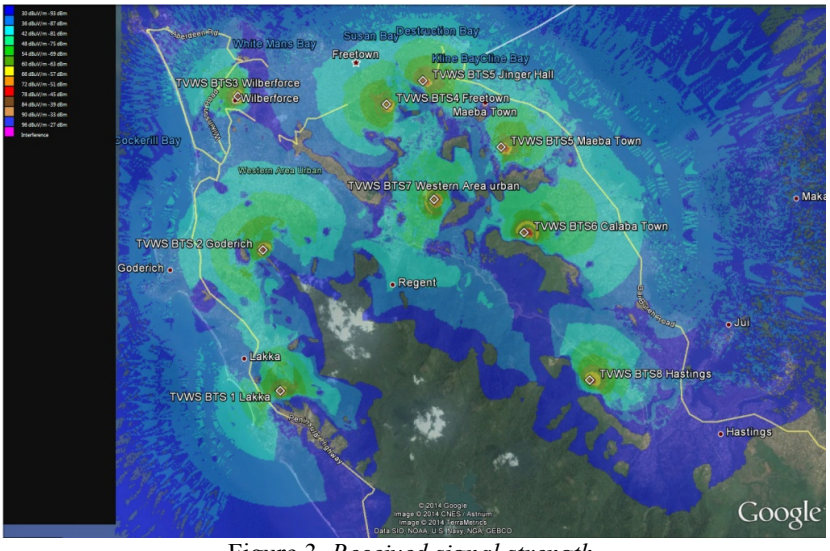

Figure 3. *Received signal strength*.

Overall throughput supported at any point of the city area covered by TVWS signal is presented in Fig.4. It can be concluded that 2.5Mb/s could be provided to any TVWS system user. Further improvements could be made deploying access control procedures and by rising oversubscription factor.

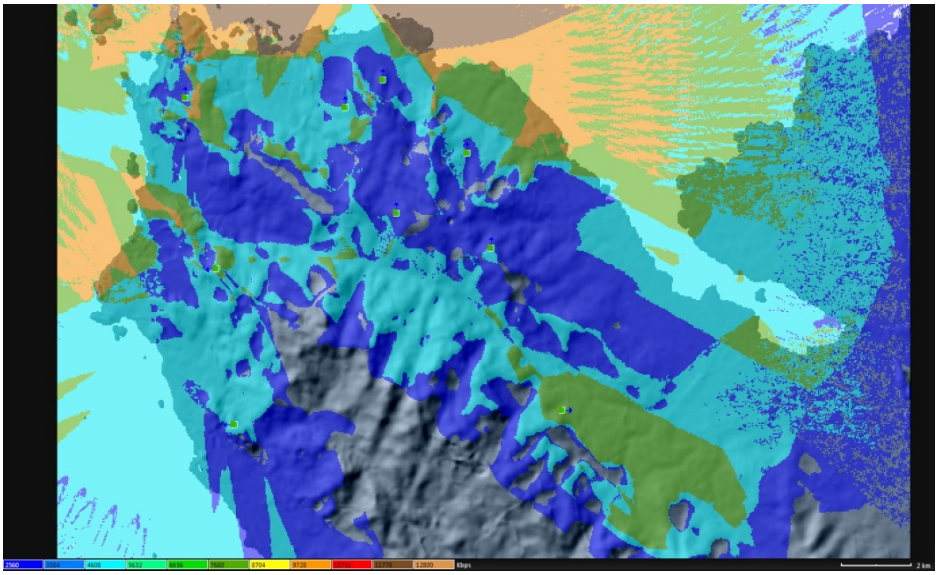

Figure 4. *Available throughput in the TVWS network in Freetown*.

Provided minimum capacity of 2.5Mb/s per CPE is enough for backhauling Wi-Fi service at the CPE locations in order to distribute available capacity and to support the basic services like Internet access and data upload. Although this data rate is not high, it is comparable to 2G/3G networks throughputs. Also, this throughput is provided to completely new locations, without telecommunications infrastructure.

3. Conclusion

Deployment of TVWS systems is fast and relatively simple. Because of that, they present ideal candidates for deployment in emergency situations, in the areas where reliable telecommunications services area not available. Achieved throughputs are competitive to the existing wireless systems. Although not highest available comparing to some recent improvements in 3G and 4G networks, these throughputs are more than enough to allow upload of data (e.g. patients data from the temporary hospitals), Internet access or streaming of movies with lower resolution at the information kiosks.

In the case of Freetown, with only 9 BTSs, city coverage has been achieved. Such network could be deployed fast, covering existing hospitals and new micro ones that are of temporary character. After fighting disease, TVWS system could be used as fixed wireless system for general population in Freetown.

Literature

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Abstract: *Slobodan spektar u TV opsegu ima veliki potencijal kada se posmatra primena sistema u vanrednim situacijama. Do sada su sistemi koji rade u TVWS opsegu opisivani sa aspektra standardizacije i unapređenja karakteristika. Vidljiv je nedostatak radova na temu njihove konkretne primene. Opisana je primene sistema koji rade u TVWS opsegu i dat je primer u slučaju primene u slučaju borbe protiv zaraze. Može se zaključiti da uz malu investiciju, u kratkom vremenskom roku, TVWS sistemi mogu biti izgrađeni i pušteni u rad u vanrednim situacijama koji su konkurentni protocima u Wi-Fi mrežama i mrežama mobilnih operatora.*

Keywords: *Slobodan spektar u TV opsegu, projektovanje mreže, vanredne situacije*

PRIMENE TVWS SISTEMA

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