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Using TV white space spectrum to practise telemedicine: A promising technology to enhance broadband internet connectivity within healthcare facilities in rural regions of developing countries

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Abstract

The following correspondence provides an overview of TV White Space (TVWS) technology, regulations, and potential applications to the health care sector. This report also introduces "Project Kgolagano," a Botswana-based initiative representing the first endeavour to utilize TVWS internet connection for practising telemedicine. TV "white space" refers to the previously unused, wasted spectrum within TV radiofrequency channels that can now be leveraged to obtain broadband internet access. TVWS represents a less costly, faster, and farther-reaching internet connection that is a promising option for connecting the previously unconnected populations of remote and underserved areas. The Botswana-University of Pennsylvania Partnership, Microsoft, Botswana Innovation Hub, Vista Life Sciences, and Global Broadband Solutions have partnered together to bring TVWS wireless broadband access to healthcare facilities in poorly connected regions of Botswana (Lobatse, Francistown, Maun, Gaborone) in order to improve healthcare delivery and facilitate telemedicine in dermatology, cervical cancer screening, and family medicine (HIV/AIDS, TB, general adult and pediatric medicine).

Keywords

Remote consultation, telemedicine, telehealth, ehealth

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The use of telemedicine in the developing world and other resource-poor settings may have a profound impact on medical care and education in remote or underserved areas.[1] As telemedicine increasingly relies on two-way video, high-resolution photographs, and internet-based technologies to transmit data and interact remotely, reliable broadband connection is imperative in ensuring successful and efficient information transfer. Unfavourable internet connectivity may result in poor audio and visual quality leading to potential diagnostic inaccuracies, delays in care, and user frustration.[2,3] In Africa, especially in underserved and rural areas, ubiquitous internet access remains a challenge due to barriers such as lack of infrastructure and high cost.[4] Furthermore, although mobile telemedicine using mobile data connectivity may be useful in some areas, it is limited and inconsistent in rural areas, thereby limiting the full potential for high quality telemedicine encounters and rural–urban healthcare equality.

The use of TV-band white spaces (TVWS) via dynamic spectrum access to deliver 'Super Wi-Fi' is a promising recent option for achieving affordable, universal broadband internet access, particularly in rural and underserved regions. TVWS has been successfully piloted around the world in educational, agricultural, and commercial sectors and is highly recognized in computer sciences and engineering literature.[5] However, its advantages and applicability in bridging the digital divide within healthcare and

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telemedicine are largely undocumented. In fact, literature searches conducted across PubMED, including the *International Journal of Telemedicine and Applications*, *Telemedicine and e-Health*, and the *Journal of Telemedicine and Telecare*, displayed no relevant search results for 'TV white space'.

Our organization, the Botswana–UPenn Partnership (BUP), in collaboration with the Botswana Ministry of Health (MOH), Microsoft, Botswana Innovation Hub (BIH), Global Broadband Solutions (GBS), Bofinet, and Vista Life Sciences (VLS), aims to investigate the utility of TVWS connectivity in improving telemedicine practices in urban and rural Botswana healthcare facilities. TVWS technology has never before been implemented in Botswana, and at the time of writing this paper, no publications have ever assessed the use of TVWS in healthcare.

Overview of TVWS technology

In 2011, the UN declared internet access a basic human right.[6] Subsequently, there has been a growing demand on the amount of radiofrequency spectrum and bandwidth necessary to sustain the increasingly congested network. Conventional fixed spectrum policies allocate spectrum to licensed users and are unable to meet these needs due to high cost and inefficient utilization of spectrum.[7] Television channels operate on designated, licensed, sub-1 GHz spectrum that differs by country within known radiofrequency bands referred to as VHF (30–300 MHz) and UHF (300–3000 MHz),[8] but to avoid interference between channels, certain frequencies exist but are not used. These wasted idle frequencies are referred to as 'white space' and may be geographically detected by cognitive radios via a process called spectrum sensing or by determining spectrum availability by accessing a database that informs the device on spectrum availability based on its geo-location.[9] Cognitive radios are intelligent communication devices capable of identifying unused spectrum within their radio environment and autonomously coordinating the assignment of spectrum according to regulatory rules.[10] The unused channels may then be opportunistically used for wireless communication by secondary, unlicensed users depending on local availability and impending government regulations. This process of 'recycling' spectrum is referred to as dynamic spectrum access, and poses a promising, less costly solution to increasing the available radiofrequency spectrum.[11]

TV broadcast channels within VHF/UHF bands are especially desirable due to superior propagation characteristics such as the ability to travel long distances with superior speeds and enhanced penetration of walls and other barriers. The estimated bandwidth is 5.22 MHz, and the maximum channel capacity (data rate) and distances achieved vary based on the power of the TVWS device being used (low transmission-power mobile devices versus 2.4 GHz devices, 5.5 GHz devices, or high power TVWS-fixed devices), the terrain, obstacles, and number of users. High power fixed TVWS devices may reach distances of 1200 m with a channel capacity of slightly less than 100 Mb/s and other TVWS devices may reach 600 m at less than 50 Mb/s.[12] In low-density populations where general availability of 'white space' is high and fewer broadband access options exist, TVWS technology is particularly attractive. Due to these attributes, the application of TVWS is well suited to rural and underserviced environments that are typically remote and lacking in telecommunications networks.[12] The benefits of TVWS, however, are not limited to rural regions. Even in urban settings, the use of TVWS may be useful in offloading the number of users on the overwhelmed unlicensed spectrum, leading to better Wi-Fi and mobile network performance.[13] In addition, TVWS spectrum offers a new avenue for enabling and supporting a variety of emerging applications for the 'internet of things', ranging from smart grid, public safety and broadband cellular, to medical applications such as wearable computing devices.[14]

TVWS has currently been piloted in the USA, UK, Philippines, South Africa, Kenya, Tanzania, Ghana, Singapore, Malawi, Zambia, Finland and other countries, and has been shown to provide an effective internet connection without interfering with licensed spectrum holders.[5] At the time of drafting this letter, the US Federal Communications Commission (FCC) has already adopted non-exclusive licence-exempt access to TVWS, and regulators in the UK, Canada, South Africa and other countries have begun to implement the necessary changes to commercialization of TVWS.[5,9,15,16] In 2009, the FCC created a notice of public rulemaking (NPRM) proposing allocation of spectrum for MBANS (medical body area networks), which are networks of wearable computing devices that transmit medical data.[17] In 2012, a first report and order was issued to expand these rules to include allocation of MBANS within the TVWS frequency band 2360–2400 MHz.[18] In 2013, a petition for rulemaking was presented to request that the FCC adopt administrative and physical safeguards to facilitate Health Insurance Portability and Accountability Act (HIPAA) compliance in relation to this NPRM;[19] however, FCC rulemaking proceedings are still not yet complete. The 2009 American Recovery and Reinvestment Act (ARRA) section on the Health Information Technology for Economic and Clinical Health Act (HITECH Act) provides the most current guidelines to promote the adoption and meaningful use of health information technology and should be considered when utilizing TVWS internet connection for medical purposes. The act widens the scope of privacy and security protections available under HIPAA, increases the potential legal liability for non-compliance, and provides more enforcement.[20]

Project overview

An agreement was reached between the BUP, Microsoft, BIH, VLS, GBS and Bofinet, thereby signalling the

commencement of 'Project Kgolagano', which was publicly launched in March 2015. Translated into English, the Setswana word 'Kgolagano' means 'to connect', which embodies the overarching goal of the project: to use TVWS technologies for leveraging unused/unassigned TV-band spectrum to bring wireless broadband access to poorly connected regions of Botswana (Lobatse, Francistown, Maun, Gaborone), in order to improve healthcare delivery. Pending successful implementation of TVWS in these regions, the project may be scaled in the future to include other regions such as Kang, Nata and Chobe.

Like many developing countries, healthcare delivery in Botswana via wireless telecommunication services is currently challenged by non-robust IT infrastructures and slow bandwidth. Despite this, Botswana has recently experienced tremendous growth in the mobile telecommunication industry and is one of the first countries in Africa to invest in a nationwide mobile telemedicine scale-up project, 'Kgonafalo', which is being undertaken by BUP, the Botswana MOH, the Orange Foundation of Botswana and 5AM Consultancy group.[21] Kgonafalo currently covers four specialties including radiology, oral medicine, dermatology and cervical cancer screening; however, the proposed telemedicine specialties for the TVWS study will include cervical cancer screening, dermatology, and family medicine (HIV/AIDS, TB, general adult and paediatric medicine). Unfortunately, telemedicine initiatives presently suffer unfavourable internet connectivity, resulting in poor audio and visual quality, and current practices are limited to asynchronous 'store and forward' techniques because the existing IT environment cannot support more data-dependent means such as live, interactive video streaming.[22] The TVWS project will build upon and supplement the initial work started with Kgonafalo.

We will use a combination of technical studies, surveys, observational studies, and focus groups to investigate the value of TVWS for telemedicine usage and medical information acquisition within the healthcare setting. This study will investigate the internet environment and associated challenges before and after the installation of TVWS devices within selected Botswana healthcare facilities. We will use qualitative and quantitative methods to elicit information on the benefits, challenges and perceptions of the telemedicine system made possible by the TVWS internet connection.

Conclusion

Despite the significant promise for bolstering healthcare delivery and telemedicine practices in resource-poor settings, the paucity of publications related to TVWS within the medical literature suggests an apparent lack of awareness regarding TVWS technology in the public health sector. It is our opinion that this topic warrants further attention and discussion because TVWS is projected to reach commercial markets within the next few years, and the medical community should be aware of its utility and be prepared to maximize the TVWS opportunity. In addition, because TVWS regulations have not yet been established by many African or other nations, documenting the potential benefits of TVWS is imperative to encouraging regulatory governing bodies to establish licence-exempt access for TVWS usage to appropriate users.

Declaration of conflicting interests

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