Wireless Edge Network for Sustainable Rural Community Networks

Adisorn Lertsinsrubtavee
intERLab
Asian Institute of Technology

Nunthaphat Weshsuwannarugs
intERLab
Asian Institute of Technology

Nisarat Tansakul
intERLab
Asian Institute of Technology

Attaphongse Taparugssanagorn
ICT Department
Asian Institute of Technology

Kanchana Kanchanasut
intERLab
Asian Institute of Technology

ABSTRACT

We have introduced a cost-sharing model for remote communities to share their limited access to the commercial Internet among community members using wireless mesh networks in the north-west of Thailand to expand the edge network coverage and to reduce the Internet cost for the rural users. However, there are places within these communities which have not been able to access our network due to the line-of-sight and the distance from the rest of the communities. In this paper, we describe our attempt or work-in-progress to address these challenges by experimenting various access technologies such as TVWS and small cell LTE as well as improving the user experience with CDN.

1 INTRODUCTION

TakNet [8] is one of the successful CWMN (Community Wireless Mesh Network) projects in terms of its impacts and improvements to people's lives in the north west of Thailand. The key success of TakNet can be summarised as 1) the system and technology is simple enough for local technicians to maintain: 2) the monthly cost is affordable for the low income users. The current technology of TakNet is based solely on CWMN with mobile routers running OLSR routing protocol [7] creating a wireless mesh network across the village and share the Internet access with one or two fiber or ADSL gateways. This has introduced significant limitations due to the nature of the WiFi radio transmission, especially in the non-line-of-sight (nlos) area or nodes that are out of range of other nodes and the hidden terminal problem leaving a number of inaccessible households on our map. In this paper, we describe our work-in-progress to connect these isolated households, which is mandatory for the sustainability of TakNet, using a combination of technologies: TVWS, small cell LTE and CDN.

ANRW '18, July 16, 2018, Montreal, QC, Canada

ACM ISBN 978-1-4503-5585-8/18/07…$15.00
https://doi.org/10.1145/3232755.3232782

2 TAKNET WITH TVWS

Before embarking on TVWS, we deployed spectrum measurements in many locations of Tak province to identify the available channels that can be used for our TVWS trial. We use the low-cost and hand-held spectrum analyser, called RF Explorer [3], installed on the raspberry Pi with timestamps and GPS locations. The spectrum usage analysis over UHF channels (channel 26 - 60) at Thai Samakhee village (lat, long GPS location: 16.794, 98.597) was conducted from the measurements collected over two hours from 13:00 - 15:00 which includes 1109 samples for each channel, shows that there are only three busy channels (50, 51 and 52) which were used in that area.

We have thus decided on experimenting TakNet coverage utilising the excellent radio characteristics of TVWS to cover the gap that our earlier CWMN could not support. In our deployment, we intend to use an LTE small cell operating on the UHF 700 band (736.5-743.5 MHz), called E40 [1]. The LTE small cell can support the bandwidth up to 75/25 Mbps with the maximum 16 active users while its maximum coverage area is about 4 km. As for the end user device, each villager can simply use his/her mobile phone attached with a TakNet sim card to retrieve the cellular connection. The villager can also use the mobile WiFi hotspot (MiFi) to share the cellular connection to other WiFi devices. Notice that 700MHz band is commonly supported by commodity devices in the market.

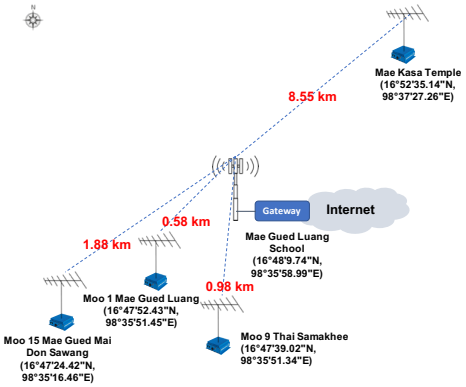

Figure 1: TVWS deployment

The TV UHF band in developing countries is significantly underutilised [10–12], and its radio propagation characteristics are much better than the unlicensed WiFi (2.4/5GHz) band [9]. TakNet aims to utilise these excellent characteristics of TVWS to provide the middle mile access from the Internet gateway to the remote villages.The TVWS link based on IEEE 802.11af [6] can cover the long distance (i.e., 10-15 km), even line-of-sight is not available. We are currently working with NBTC, Thailand regulator to deploy the first TVWS trail in Thailand by using Carlson Gen3 equipments [4]. Similar to our LTE solution, the middle mile TVWS link is also operated in 700 band with 8 MHz channel spacing. Figure 1 illustrates the locations of our TVWS trail. The TVWS base station is located at Ban Mae Gued Luang school which have two fiber connections for Internet access. The first link (100/100 Mbps) is provided by UniNet [5] and the second link (200/200 Mbps) is connected to the commercial ISP. The gateway at Ban Mae Gued Luang school also uses the load balancing to share the outgoing traffic on both links. We will connect 4 rural villages, as shown in Figure 1, to this gateway for Internet access. The longest TVWS link in our deployment is about 8.55 km which connects Mae Kasa Temple community to the Internet gateway. TVWS will act as TakNet's core network while the LTE small cells provides the last meter accesses to the users that CWMN could not cover.

3 CONTENT DISTRIBUTION SERVICE

As Internet connectivity is shared among increasing number of users in TakNet with more bandwidth greedy applications, our limited connectivity to the Internet can become slow and highly intermittent. As a result, users accessing the contents (e.g., soap opera, news, coursewares) from rural villages could experience very poor quality. To alleviate this problem, we are introducing a content distribution service where the contents or services can be delivered from the content and service providers to the rural villages. As shown in Figure 2, rural villages are connected to the Internet Exchange Point, BKNIX [2] based in Bangkok, via the VPN connection. To interoperate the content delivery between the content providers and rural networks of TakNet, we deploy our main content server at the BKNIX side and at least one content server in each community while these servers form a distributed cache sharing contents among themselves locally. Hence the contents belonging to the community's interests can be pushed and kept closer to the users for effective disseminations. We have implemented these caches storing video contents using either high-capacity dongles attaching to our mobile routers/access points or raspberry Pi where the users can access the contents via web servers running on either raspberry Pi or web server-enabled access points. Content push and prefetching activities are done during the off-peak hours at night when not many users are online. The web access logs can be analysed such that the contents similar to the highly accessed ones can be prefetched in order to meet the community needs.

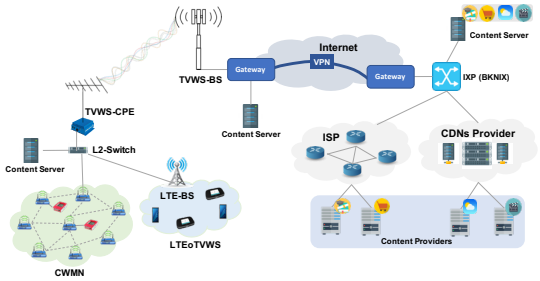

Figure 2: The overview of TakNet architecture

4 CONCLUSION

TakNet is the pioneer in deploying CWMN to provide an economically affordable solution for Internet connection in the rural area of Thailand. From our invaluable five years of experiences, we have discovered several challenges that require more concrete solution to support the growth of the network and self-sustainability. Our new TakNet architecture that combines multiple access technologies such as wireless mesh network, TVWS (802.11.af) and LTE over TVWS for providing resilient infrastructure in challenged network environment (e.g., nlos, hidden terminal). On top of that, TakNet also run a content delivery network which can offer fast and reliable content and service delivery from IXPs to the rural villages. This means day-to-day core activities of community members like watching video streaming or accessing to popular websites are supported. We are currently working on a project with the Thai regulator on the first experimental TVWS trial in Thailand as well as planning to introduce local services in Thai language for the users in the very near future.

ACKNOWLEDGMENTS

This paper has been supported by the Broadcasting and Telecommunications Research and Development Fund for the Public Interest, Thailand through the "TV White Space" project (B2-2-04/58) and THNIC foundation.

REFERENCES

[1] [n. d.]. E40 nanoLTE. ([n. d.]). Retrieved 2018-03-25 from http://www.ipaccess.com/en/viper/enterprise-small-cells

[2] [n. d.]. The first neutral Internet Exchange Point (IXP) in Thailand. ([n. d.]). Retrieved 2018-03-25 from https://bknix.co.th/en/

[3] [n. d.]. RF Explorer Handheld Spectrum Analyzer. ([n. d.]). Retrieved 2018-03-25 from http://rfexplorer.com

[4] [n. d.]. RuralConnect Gen 3. ([n. d.]). Retrieved 2018-03-25 from https://www.carlsonwireless.com/ruralconnect/

[5] [n. d.]. UniNet: Thailand Information Network for Education. ([n. d.]). Retrieved 2018-03-25 from http://www.uni.net.th

[6] A. B. Flores, R. E. Guerra, E. W. Knightly, P. Ecclesine, and S. Pandey. 2013. IEEE 802.11af: a standard for TV white space spectrum sharing. *IEEE Communications Magazine* 51, 10 (October 2013), 92–100. https://doi.org/10.1109/MCOM.2013.6619571

[7] P. Jacquet, P. Muhlethaler, T. Clausen, A. Laouiti, A. Qayyum, and L. Viennot. 2001. Optimized link state routing protocol for ad hoc networks. In *Proceedings. IEEE International Multi Topic Conference, 2001. IEEE INMIC 2001. Technology for the 21st Century.* 62–68. https://doi.org/10.1109/INMIC.2001.995315

[8] Adisorn Lertsinsrubtavee, Liang Wang, Arjuna Sathiaseelan, Jon Crowcroft, Nunthaphat Weshsuwannarugs, Apinun Tunpan, and Kanchana Kanchanasut. 2015. Understanding Internet Usage and Network Locality in a Rural Community Wireless Mesh Network. In *Proceedings of the Asian Internet Engineering Conference (AINTEC '15)*. ACM, New York, NY, USA, 17–24. https://doi.org/10.1145/2837030.2837033

[9] David Lloyd Johnson, Natasha Zlobinsky, Albert Lysko, Mokwape Lamola, Senka Hadzic, and Richard Maliwatu. 2016. Head to head battle of TV White Space and WiFi for connecting developing regions. *e-Infrastructure and e-Services for Developing Countries, Springer* (12 2016).

[10] Albert Lysko, Moshe Masonta, Mofolo Mofolo, Luzango Mfupe, Litsietsi Montsi, Fisseha Mekuria, Ntsibane S. Ntlatlapa, David L. Johnson, Dumisa Ngwenya, Andy Lee, Charlie Hardin, and Arno Hart. 2014. First Large TV White Spaces Trial in South Africa: A Brief Overview. In *International Congress on Ultra Modern Telecommunications and Control Systems and Workshops*, Vol. 2015.

[11] Chomora Mikeka, Justice Stanley Mlatho, Martin Thodi, Jonathan Pinifolo, Dereck Kondwani, Lloyd Momba, Marco Zennaro, AndrÃĪs Arcia-Moret, Carlo Fonda, and Ermanno Pietrosemoli. 2014. Preliminary Performance Assessment of TV White Spaces Technology for Broadband Communication in Malawi. *Procedia Engineering* 78 (2014), 149 – 154. https://doi.org/10.1016/j.proeng.2014.07.051 Humanitarian Technology: Science, Systems and Global Impact 2014, HumTech2014.

[12] G. Naik, S. Singhal, A. Kumar, and A. Karandikar. 2014. Quantitative assessment of TV white space in India. In *2014 Twentieth National Conference on Communications (NCC)*. 1–6. https://doi.org/10.1109/NCC.2014.6811306