SPECTRUM DETECTION FOR UKM'S CAMPUS TRANSPORTATION NETWORK BASED ON TV WHITE SPACE

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Abstract—TV White Space refers to the unused TV frequencies in the VHF and UHF band. This technology will try to use the unoccupied TV spectrum frequency for communication. The advantage of its long distance propagation and the capability of TV signals to penetrate far into the woods and go through water surface is the reasons why it is chosen as an alternative for rural communication system. In the past recent years, some applications of TVWS has been introduced to the market such as health monitoring system, low power broadband using 802.11af and remote monitoring. The objectives of this study is to identify and evaluate the potential of TVWS application on UKM’s Campus Transportation Network Services. The spectrum measurement will focus on Ultra High Frequency (UHF) band using portable RF Explorer Spectrum Analyzer and Touchstone Pro. A link budget study were carried out using Radio Mobile software to simulate the Data Link reliability and possible network coverage based on RuralConnect Equipment from Carlson Wireless. We found that the UHF spectrum at all selected locations are underutilized and there are high potentials of TVWS applications that can be carried out using this unused frequencies.

Keywords—TVWS; unoccupied TV Spectrum Frequency; Campus Transportation Network; Network Coverage; Underutilized.

1. INTRODUCTION

Internet access on public transport has become one of the attractions for commuters nowadays. In this recent years, many of public transport providers has been introducing Wi-Fi connections on their service coaches. Most of the technology still in use to accompany this service are based on mobile network technology. However, wireless technology phenomenon such as smart phones, laptops, tablets and other wireless mobile device has caused rapid increased in radio spectrum sources usage and this led to congestions of available spectrums. To overcome the high demand and making sure service quality is in a top notch condition, many alternatives has been on probe. One of most discussed technology is [1] Cognitive Radio (CR) dan TV White Space (TVWS).

TVWS is referred to the unused TV frequency in the VHF and UHF band. This technology will try to use back all the unused TV frequency band [2]. The ability to penetrate across thick woods and long distance propagation is the main reason TVWS is chosen to be an alternative especially for rural telecommunication system. In this past
recent years, few applications of TVWS has been introduced such as Rural Health Monitoring, Low Power Broadband and Remote Monitoring. Aside from that, there are many other research on TVWS applications still going on such as Security-Smart-Seamless (SSS) Public Transportation Framework for Qatar Using TV White Space (TVWS) [3]. This research focused on using IEEE 802.22 to provide surveillance camera in public bus and train system. It is also used to provide free internet access to all commuters.

In this work, we investigate the spectrum occupancy of UHF band TV channels covering frequency from 470MHz to 798MHz in three selected locations for UKM’s Campus Transportation Network. The three main locations are Faculty of Engineering and Build Environment Building (FKAB), UKM’s Commuter Station (KTM UKM) and Hentian Kajang. The objectives are (i) to identify TVWS occupancies at the selected location (ii) to analyze the spectrum utilization and (iii) to simulate the Link Budget and coverage area for all selected locations.

The rest of the paper is organized as follows. Section II presents the measurement and simulations methods used in this study. Section III will cover the results of measurement and simulations outcome. Lastly, conclusion and future works in Section IV.

2. DATA MEASUREMENT

The measurement was performed outdoor at three selected location using portable RF Explorer Spectrum Analyzer and Touchstone Pro Software. In this procedure, 41 channels of Ultra High Frequency (UHF) band was measured to identify potential TVWS channels available. The three selected locations was proposed to be place with one Customer Premise Equipment (CPE) at FKAB and two Access Point (AP) at KTM-UKM and Hentian Kajang. Fig.1 demonstrates the measurement locations while Fig.2 demonstrates the connection diagram for TVWS Campus Transportation Network.

![Figure 1. Measurement location](image-url)
Portable RF Explorer was chosen for this measurement for its user friendly features, portability, affordable cost and the ability to cover all TV frequencies[4]. This device can scan spectrum frequency from 240Hz to 960MHZ using Nagoya NA-773 antenna. A threshold value of -94dBm was selected based on the value suggested by IEEE 802.22[5][6] and Carlson Wireless Equipment specifications on Analog TV threshold [7]. Table 1 shows the specification of RF Explorer Equipment used.

Table 1: RF Explorer Equipment Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>3G Combo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum Analyzer</td>
<td>240-960 (left)</td>
</tr>
<tr>
<td>Baseline Model</td>
<td>WSUB1G</td>
</tr>
<tr>
<td>Expansion Module</td>
<td>RFEMWSUB3G</td>
</tr>
<tr>
<td>Frequency</td>
<td>1.0</td>
</tr>
<tr>
<td>Amplitude</td>
<td>0.5</td>
</tr>
<tr>
<td>Graphics LCD</td>
<td>128x64</td>
</tr>
<tr>
<td>RF Impedance</td>
<td>50</td>
</tr>
<tr>
<td>DSP</td>
<td>Filter/Fast</td>
</tr>
<tr>
<td>Amplitude stability</td>
<td>+1dBm</td>
</tr>
<tr>
<td>Amplitude accuracy</td>
<td>+3dBm (left)</td>
</tr>
<tr>
<td>Max RF DC</td>
<td>16V</td>
</tr>
<tr>
<td>Windows PC Client</td>
<td>32/64 bits</td>
</tr>
<tr>
<td>RS232/USB API</td>
<td>Yes</td>
</tr>
<tr>
<td>Antennas included</td>
<td>NA-773</td>
</tr>
</tbody>
</table>

Source: http://j3.rf-explorer.com/
A Link Budget study based on Carlson Wireless RuralConnect Equipment was performed to evaluate the reliability of the data link connection of all measured location. The simulation was done by using Radio Mobile Online at http://www.cplus.org/rmw/rmonline.html. It is a radio wave propagation prediction tool that uses digital terrain information and mathematical model to simulate radio transmissions between two fixed sites. Its databases consist of land cover, population density and ground elevation information in order to predict radio transmission performance.

3. RESULTS AND ANALYSIS

The results based on methodology outlined at section II have been recorded and plotted as Figures 3-5 below, followed by discussion of the result.

![Figure 3: Measurement at FKAB Building (542MHz)](image3)

![Figure 4: Measurement at FKAB Building (710MHz)](image4)
Figure 3 shows an occupied channel measured at FKAB. The signal matches a basic composite video signal with signal strength above the threshold margin. Whereas, Figure 4 shows an unoccupied channel at 710MHz. Figure 5 shows Average RSSI (dBm) vs Frequency of all channels. It is clearly seen that from this graph, a large number of channels in the frequency range of 646MHz to 798MHz frequency is not being used. Note that there are two Threshold margins used in this study as explain earlier in section II. The other reason of using much lower threshold is to protect TV receivers in worst-case fading scenarios where a TV signals is received with weak signals as mention by Yin et al [8]. On the other hand, a too conservative settings as suggested by Ofcom [9] will result in smaller portion of occupancy.

Further analysis, finds that the utilization for threshold of -94dBm resulted 0% both for FKAB and KTM UKM. 7.31% for Hentian Kajang. Whereas by lowering the threshold value to -95.68dBm, we found that the utilization increased at KTM UKM with 2.44% and Hentian Kajang with 12.20%. This conclude that choosing a slight variation in threshold can results in number of White Space vacancies found as mention by Yin et al [8].

The Link Budget simulation results as demonstrated in Table 2. shows that both communication link are feasible to deploy. Note that both Fade Margin value is above minimum suggested Fade Margin value that is 10dB to ensure link performance.
Table 2: Link Budget Results

<table>
<thead>
<tr>
<th></th>
<th>FKAB to KTM UKM</th>
<th>FKAB to Hentian Kajang</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance</strong></td>
<td>2.141 km</td>
<td>4.009 km</td>
</tr>
<tr>
<td><strong>Total Path Loss</strong></td>
<td>104.42 dB</td>
<td>102.45 dB</td>
</tr>
<tr>
<td><strong>Fade Margin</strong></td>
<td>44.87 dB</td>
<td>25.08 dB</td>
</tr>
<tr>
<td><strong>Rx signal (dBm)</strong></td>
<td>-48.15 dBm</td>
<td>-67.94 dBm</td>
</tr>
<tr>
<td><strong>Rx Sensitivity</strong></td>
<td>-93.02 dBm</td>
<td>-93.02 dBm</td>
</tr>
<tr>
<td><strong>Rx Antenna Gain</strong></td>
<td>9 dBi</td>
<td>9 dBi</td>
</tr>
</tbody>
</table>

Figure 6: Coverage Area from FKAB

Last part of the simulation is Radio coverage probability based on specification of Carlson Wireless Yagi Directional Antenna. Although radio coverage simulation cannot be guaranteed 100% true, it still is crucial in radio spectrum planning as we can estimate the coverage area. Figure 6 shows the coverage area of a Yagi Directional Antenna by Carlson Wireless that has been suggested in this study. The Green Color area is a Strong Signal Coverage sign and Red color means weak Signal Coverage sign. We can see from Figure 6, most of the area from FKAB towards Hentian Kajang is covered in this simulation results. Table 3 demonstrate the specification of the antenna used in this simulation.
4. CONCLUSION

We are able to measure and record all UHF channel at the selected site. We found out that most of the UHF spectrum channel at all three location is not being optimumly utilized. This unoccupied TV spectrum channel can be used for Campus Tranportation Network based on TVWS technology especially in the UHF band. For future works, we suggest to use all information from this study to be used in UKM Campus Transportation Network Prototype. Another important aspect is to further study the mobility for TVWS nodes from moving bus campus.

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Bibliography

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