A road map for wireless mesh routing with DSA

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***Abstract*—Dynamic Spectrum Access (DSA) provides a new opportunity for last-mile and rural connectivity. However, the nature of DSA and varying environmental conditions means that desired spectrum is not always available. To that end, we have deployed a testbed using both DSA-enabled TV White Space devices and fixed spectrum WiFi (5GHz) in parallel to support communication between and within townships. Using this testbed, we will develop new algorithms to support wireless mesh routing in DSA networks.**

***Keywords*— wireless mesh routing, dynamic spectrum access, multi-radio systems, rural connectivity**

I. Introduction

Traditionally, regulators assign frequencies for electromagnetic radio spectrum users to operate in. Users have exclusive access and these assignments remain unchanged over the license validity period. In line with regional or national regulation, manufacturers pre-set the spectrum band in which wireless devices operate. Owing to the shortcomings of the Fixed Spectrum Assignment (FSA) method, numerous proposals [1, 2, 3] have been made recently that propose Dynamic Spectrum Access (DSA) techniques. DSA is a new spectrum assignment approach where devices make real-time adjustment of spectrum usage to adapt to changes in the spectral environment or performance objective. DSA has also been suggested as one of the techniques to be used in 5G networks. DSA has potential to allow unlicensed users to access licensed parts of the spectrum on a secondary basis when not in use by the primary/licensed users. The term *white space* is used to describe the parts of spectrum that are vacant either spatially or temporarily. Though present in any spectrum band, the current emphasis is on the television band because this is where the most significant white space is found. We refer to this spectrum as television white space (TVWS).

II. Relevance of wireless communication to emerging markets

Among the available options for the last mile, the roll-out cost of wired links is comparatively high. In addition, the infrastructure might be targeted by thieves because of the high value of copper cables. Fibre-optic communication is another possible alternative but for low-income communities the capital required to set it up renders it less viable for extension beyond the Point-of-Presence (POP). In addition, the terrain in some cases makes the implementation of wired infrastructure in rural areas impractical. Very Small Aperture Terminal (VSAT) is capable of covering remote areas but the required initial and recurring costs are prohibitive. Therefore, open spectrum wireless access technology offers the most hope in extending connectivity to rural areas [4].

For DSA to work, it requires provisioning across at least two dimensions: regulation and hardware/software support. With the continued increase in the development of wireless applications in the recent past, a trend that has shown no signs of slowing down, DSA is the preferred approach because it promises efficient spectrum utilisation and eliminates the complexities associated with static frequency assignment planning that would otherwise be required for large scale ad-hoc networks. The benefits of DSA based communication build on the advantages that wireless mesh networks hold, which includes comparatively low upfront costs, self-configuration, robustness, and easy set-up, expansion and maintenance.

III. Problem statement

A network is to be designed and built that makes optimal use of spectrum and routes traffic over optimal paths. The network must be self-configuring, require little maintenance and extend connectivity at low-cost.

IV. Node design

FIGURE 1 shows the node used in the outdoor testbed. The nodes have the following features:

- Multi-radio: 2.4GHz WiFi for access, 5GHz WiFi and TVWS for the back-haul.
- Support for Protocol to Access White Space (PAWS).
- Inbuilt GPS to determine position required by PAWS for querying the spectrum database.
- Inbuilt spectrum analyser for clean channel selection.

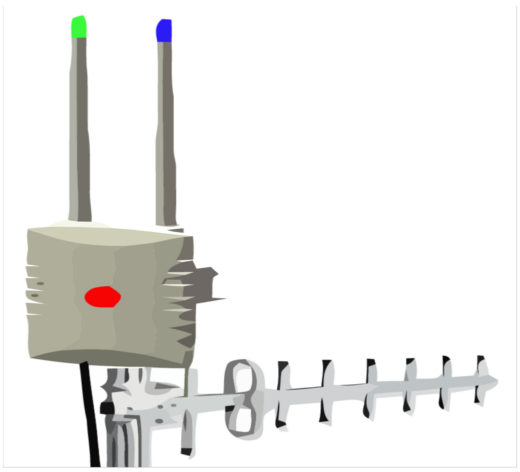

FIGURE 1: white space mesh node.

V. APPLICATION SCENARIO AND TESTBED DESCRIPTION

One major challenge in rural communities is the extension of connectivity from the nearest POP to the houses. The areas are characterised by sparse population and rugged terrain, which makes cabling or laying down optical fibre impractical in both technical as well as economic terms. This work focuses on the application of white space spectrum to extend broadband connectivity to rural communities as illustrated in FIGURE 2. Vegetation and other obstacles along the signal propagation path results in obstructed line-of-sight. FIGURE 3 shows the actual node placement of the outdoor testbed. The nodes are placed at sites in a way that provides a diverse set of available TV white space spectrum, which is useful for research. Distances between the nodes is 1-12 km.

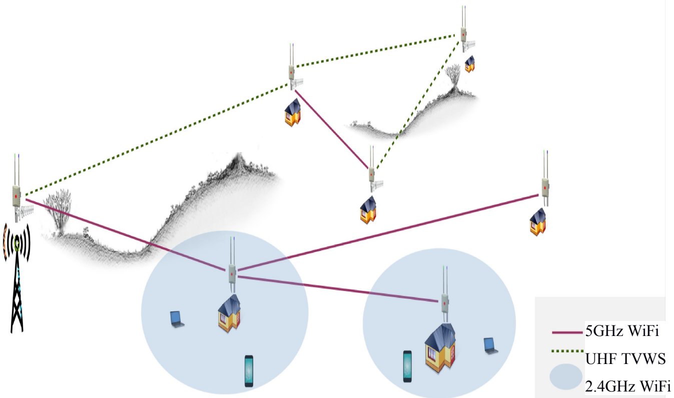

FIGURE 2: white space for rural broadband connectivity.

FIGURE 3: outdoor mesh node placement.

VI. DESIGN MOTIVATION AND CHALLENGES

The nodes consist of a 5 GHz WiFi and a TVWS radio. The idea is to use 5 GHz where we have perfect line of sight, and use a TVWS link where we have a near line-of-sight. In addition, the nodes are equipped with a 2.4 GHz WiFi interface for access as illustrated in FIGURE 2. Though there is a significant amount of white space especially in the television band, it is not guaranteed to be available at all times and at all locations. Therefore, in order to maintain connectivity in the absence of white space, our nodes consist of dual transit links i.e. a TVWS link and a fixed spectrum (5 GHz WiFi) link. The other reason for the dual-link radio design is that we envisage mesh deployments over an extensive area with varying environmental conditions such as distance, vegetation, buildings and other elements bound to affect radio signal propagation between the nodes. The intention is to auto-switch between WiFi and TVWS depending on which one thrives under the conditions at hand. Therefore, the two links can be used alternately when one fails or they can be used in concert to achieve real *full-duplex*. We define full-duplex from the node perspective as the use of one link for outbound traffic and the other for inbound traffic. The challenge is, to determine a standard of comparison between links operating in different spectrum bands so traffic can be routed over the optimal link.

VII. OBJECTIVE AND EXPECTED OUTCOME

This work aims to develop new mesh networking algorithms that are suited to DSA networks. The objective is to enhance connectivity and increase throughput. The expected outcome of this research includes improved metrics for TVWS mesh and routing algorithms for selection of TVWS or WiFi links.

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