Unified Solution Towards Deployment of TV White Space in Africa

P. Batroff, O. G. Aliu, E. Schütz, M. Kretschmer, C. Niephaus, K. Jonas

Fraunhofer FOKUS, Sankt Augustin, Germany
{philipp.batroff|osianoh.glenn.aliu|eric.schuetz|mathias.kretschmer|Christian.Niephaus|Karl.jonas}@fokus.fraunhofer.de

Abstract. TV white spaces (TVWS), are seen as a key technology to enable the efficient use of scarce sub-GHz spectrum allowing for applications that may have a huge impact on internet penetration in rural parts of Africa. We first give an overview on TVWS, its use cases and highlight possible challenges against its uptake. Then we describe our carrier-grade wireless back-hauling solution (WiBACK) and discuss its capability for working with a geolocation database ensuring zero interference with licensed users.

Key words: WiBACK, TVWS, White Space Device (WSD), Geolocation Database (GLD)

1 TV White Space

Significant efforts have been made by technology companies and development agencies to deliver cost efficient internet access to the developing areas. While the potential of improving the quality of life is higher via internet access, Africa shows the lowest penetration [1].

The challenges include deploying these technologies at a reasonable price to rural areas are among others; the huge distances to cover, a lack of infrastructure, skilled labor and low local buying power. Several technologies and concepts are addressing these points, among which is the provision of carrier grade wireless backhaul solutions. More spectrum will be required to achieve higher capacities and the global trend to make sub-GHz bands, hitherto used for TV broadcast available for wireless communication is of great interest. These bands referred to as TV White Space (TVWS), offer an interesting alternative.

There exists two main approaches towards enabling a dynamic use of the white spaces in the TV spectrum. These include the use of cognitive radios or having a geolocation database that contains information of the available white spaces. Using a database management system is the preferred option. Figure 1 gives an overview of how a TVWS based system works and summarized as

1. The existing national regulator database of licensed users in the TV bands provides an update to the geolocation database provider.

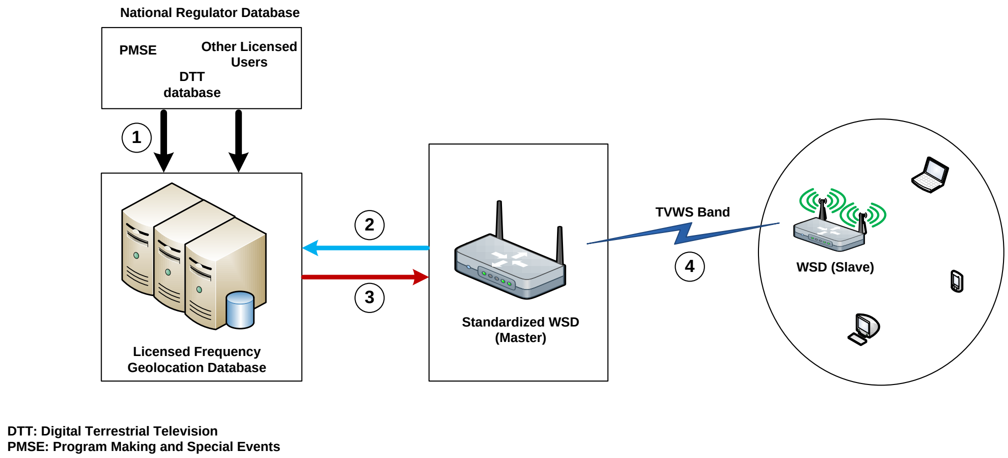

Fig. 1. TV White Space Framework

2. A standardized WSD master[1] establishes a secure link with the geolocation database [2], queries it for the set of free channels by providing its geographical location and type of device.
3. This is used to estimate the free channels in that local area and the recommended maximum transmit power.
4. With a list of available channels and allowed transmit power the master executes a channel allocation to its associated slave devices and synchronizes with the DBMS for updates.

1.1 Applications and Current Challenges

The provision of broadband connectivity in rural areas is perhaps the most relevant use case for TVWS in underdeveloped and developing regions. It provides a cost effective solution in areas where legacy operators do not have a good business model of deploying existing wireless infrastructure. Hence, the opportunity exists to provide a carrier-grade wireless backhaul solution using this band and serve as a means for coverage extension for the last-mile mobile, DSL or satellite network. Despite the huge potential of this applications a few challenges still have to be addressed for a successful deployments.

– Standardization of WSD to aid hardware manufacturers produce radios that adhere to legal requirements of operating in the TVWS bands. Furthermore, framework for authentication and prevention of unauthorized data queries or intrusion by pseudo nodes to the database needs to be clarified [2].
– Generating an accurate TVWS database is critical as any errors would lead to severe interference both for primary and secondary users.

[1] assumed placed at a fixed location such as rooftop

- Driving locally relevant applications using the TVWS bands that will create value for local communities such as platforms for connecting agricultural centers, mobile payments, e-health, etc.
- Informing the public, incumbent licensed operators and other stakeholders on proposed plans for the broadband services in the TVWS bands as well as facilitating frameworks and schedules for testing and field trials before final deployments.
- Lack of stable power supply accounts for a major cost of telecommunication operators in Africa [3]. Solutions should incorporate a green, stable and alternate sources of power supply.

Despite the challenges highlighted, using the TVWS band for broadband applications addresses the most fundamental challenge - bridging the digital divide and can be used to provide a cost efficient carrier grade wireless backhaul solution to developing and rural areas.

1.2 Ongoing Trials and Standards

The Cambridge white space trial is one of largest field trials involving 19 sites with 2 GLDs. A summary of the technical findings can be found in [4]. This report and recommendations can help guide subsequent field trials in Africa. With South Africa expected to complete the first digital switchover in Arica by December 2013, Nigeria by January 2015 and all African countries by June 2015, various TVWS field trials have already started as the awareness of its potential begins to grow. There are planned and ongoing trials in Kenya[5], Malawi [6] and South Africa[7].

Among the various standardization activities, of particular interest are the protocols required for the communication link between the WSD and the database. Specification of this interface, communication protocols and frequency of probing the database for information. [2] specifies the protocol for accessing the GLD, use cases and requirements for the protocol. IEEE 802.22 standard specifies the air interface, MAC layer and physical layer of point to multipoint wireless regional area networks, operating in the VHF/UHF TV broadcast bands [8]. For applications in the sub-GHz band, IEEE 802.11ah WG is currently developing global wireless LAN standard [9]. IEEE 802.11af is specifically addressing modifications to the existing 802.11 physical layers and 802.11 MAC layers to meet the legal requirements for channel access and coexistence in the TV white space band [10].

2 WiBACK

A heterogeneous Wireless Back-Haul (WiBACK) [2] [11, 12] architecture, which, compared to traditional fixed wireless operator back-haul networks, offers simplified deployment processes due to its flexible self-configuration and self-management

[2] http://www.wiback.org

characteristics. Those allow for the use of more cost-effective packet-switched equipment, such as IEEE 802.11, 802.16 or 802.22 and also support the integration with existing technologies such as DVB, 3GPP, micro-wave or optical solutions. The scope of the WiBACK architecture is to provide or extend existing back-haul capacity which might range from single-hop long distance wireless connectivity to multi-hop connectivity with up to ten hops in urban and rural environments. Dedicated per-hop resource allocation and are used as aggregates providing resource isolation among traffic classes as well as individual *data pipes* of the same traffic class and also to detect regulartory events, such as preemptions by primary users.

3 Proposed Tv White Space (TVWS) Integration with WiBACK

In this section we present the possible integration of the TVWS Framework with the existing WiBACK architecture with a focus on the management and maintenance of frequency utilization by the Topology Resource Manager (TRM). It consists of three major components: The Topology Management Function (TMF)(see [12]), Resource Management Function (RMF)(see [13]) and the Topology Database. We focus on a possible TVWS integration into the current WiBACK network, with special regard to the TVWS requirements of frequency allocation.

In [12] we have discussed in detail that our WiBACK architecture can support a Dynamic Broadcast system in parallel to Internet and data services by providing the mechanisms to dynamically manage the temporarily freed up wireless spectrum resources. As mentioned and shown in section 1 and figure 1, the use of a *Licensed Frequency Geolocation Database* is the preferred solution to implement and deploy sub-GHz White Space. With WiBACK using a centralized management and monitoring approach, frequency changes can be triggered by the TMF. This enables the Topology Resource Manager (TRM) to react quickly and accordingly to external demands such as frequency allocation by licensed users, in this specific case other TVWS-users. Figure 2 gives an overview on the integration of the TVWS-DataBase Management Systsem (DBMS).

To react accordingly if the TVWS-DBMS signals a change of the current channel allocation to the WiBACK network, the TMF will reconfigure the allocation to other, preferably interference-free channels in the allowed spectrum. Occupied, licensed channels can also be blacklisted by the TRM, to ensure no future collision with other licensed users for the subscription time. Based on the top level description given in this section, there exists a high level of synergy between our existing carrier grade Wireless Back-Haul (WiBACK) solution and the proposed applications of TVWS for wireless backhauling. A seamless incorporation of a geolocation database would aid our TMF to ensure resource reallocation are synchronized across the whole network with zero channel interference. Upon completion of various standardization activities, our system can be deployed on our existing testbeds in Africa.

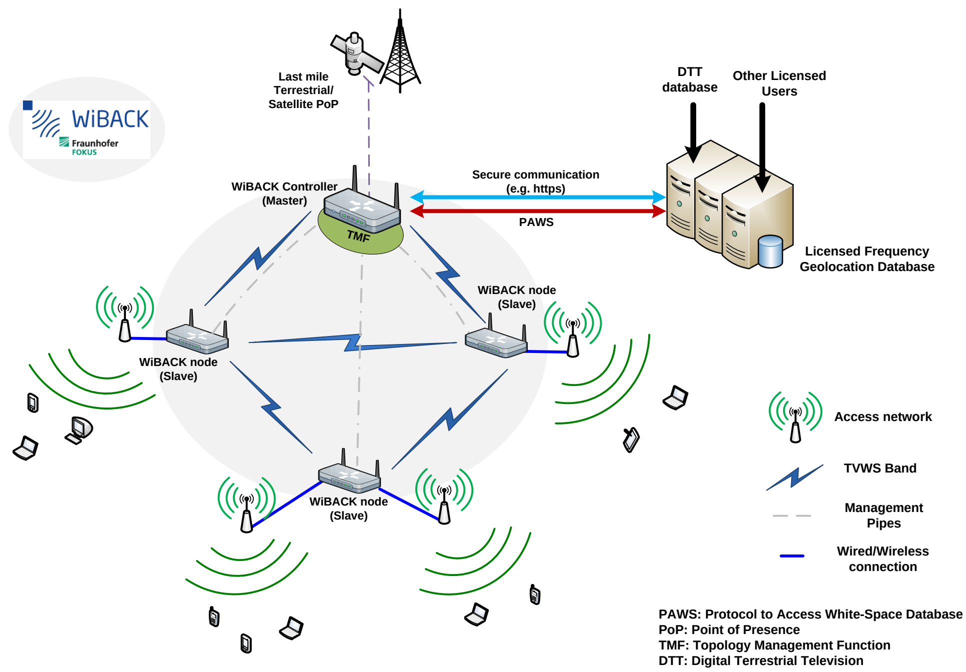

Fig. 2. WiBACK Architecture for an integrated TVWS approach

4 Conclusion

The paper described challenges of TVWS and suggested some technical approaches to integrate appropriate mechanisms in the WiBACK Wireless Backhaul architecture. We are currently working on technical solutions to be ready for deployment as soon as legal frameworks allow. Most of the technical aspects have solutions that are rather straight-forward and can easily be integrated into the existing WiBACK architecture.

However it must be noted that on the physical layer spectrum is limited in the TVWS bands. If broadband backhauling shall take advantage of that spectrum, the databases need to be very accurate and the models that describes the interference areas of a long-haul (20 km) link need to be very reliable.

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