CSIR Meraka Institute
PO Box 395 Pretoria 0001 South Africa
Tel: +27 12 841 2911
Fax: +27 12 349 1153
Email: query@csir.co.za

Lowering the cost of Access using Dynamic Spectrum Access Innovation

A Submission to Parliament's Portfolio Committee on Telecommunications and Postal Services on the Cost to Communicate in South Africa

The CSIR welcomes the Portfolio Committee's call for submissions on this important topic, which directly aligns with the goals of the National Broadband Policy:South Africa Connect (SA Connect). Specifically, the goal of reaching 90 percent of the population at 5 Megabits per second (Mbps) and 50 percent of the population at 100 Mbps by 2020 with the cost not exceeding 5 percent of the average monthly income in South Africa.

In our submission, we specifically highlight the potential that new approaches to spectrum management has to optimize the use of this valuable, non-depleting but limited resource and thereby enhancing connectivity in general and in particular in rural and other historically marginalized areas.

We conclude our submission with 4 specific recommendations that we believe will support the objectives of SA Connect and in doing so the National Development Plan.

Background

Mobile phone subscriptions globally and in Africa have shown impressive growth. Globally, subscriptions have grown from 33.9 percent in 2005 to 99.7 percent in 2016 and in Africa, subscriptions have grown from 12.4 percent in 2005 to 80.8 percent in 2016. Broadband active mobile subscriptions have also grown impressively; globally from 11.5 percent in 2010 to 49.4 percent in 2016 and in Africa from 1.8 percent in 2010 to 29.3 percent in 2016[1].

An equally impressive story is the growth of wireless local area networks (WLAN) or Wi-Fi, globally. In 2014 Wi-Fi carried 69 percent of total traffic generated for smartphones and tablets. For traditional desktop computers (PCs) and laptops, Wi-Fi was responsible for carrying 57 percent of total traffic. Ironically, the mobile industry might be the single biggest beneficiary from the data carried by Wi-Fi. In the absence of Wi-Fi, approximately 150,000 to 450,000 new radio base stations would be needed to cope with smartphone traffic – an investment of between 30 and 93 billion dollars[2]. According to Cisco's Visual Networking Index (VNI) Mobile forecast highlights for South Africa, for all Internet traffic (fixed and mobile) in 2015, 63 percent was Wi-Fi, 33 percent was Wired, and 5 percent was mobile. In 2020, 79 percent will be Wi-Fi, 12 percent will be Wired, and 8 percent will be

1 http://www.itu.int/en/ITU-D/Statistics/Pages/facts/default.aspx
2 https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/spectrum-case-for-permissive-rule-based-dynamic-spectrum-access_thanki.pdf

mobile[3].

The cost to communicate has also been steadily decreasing, globally, and in developing nations. The average cost of 1 gigabyte (GB) of computer-based or mobile-broadband as a percentage of gross national income (GNI) decreased from 8 percent to 5.5 percent approaching the International Telecommunications Union (ITU) target of 5 percent. In developing countries this decreased from 12 percent to 8 percent, and in Least Developed Countries, such as Zambia and Angola, this decreased from 33 percent to 17 percent. In South Africa the lowest cost for a 1GB basket has decreased from 14.06 dollars in quarter 2 (Q2) of 2014 to 8.37 dollars in Q2 2015 to 5.27 dollars in Q2 2016. However, in spite of South Africa being the first mobile operator in Africa out of the starting blocks, South Africa is still ranked 16th in Q2 2016 on the lowest cost for a 1GB basket in Africa (5.27 dollars) with countries like Mozambique costing 2.87 dollars and Rwanda costing 4.03 dollars[4].

What is not revealed in these national cost summaries is the lack of choice many users have in some areas to seek out lower cost connectivity. Urban users can choose between the full gambit of mobile operators or seek out free or lower-cost public Wi-Fi, at internet cafe's, libraries or even across whole cities – as in the case of Tshwane – for more bandwidth intensive use. The lowest cost access reflected in the Information and Communication Technology (ICT) Africa Study is often on a carrier not available in a specific rural area or there may be no coverage at all.

In our submission we will focus on new ways to approach spectrum management that underlies mobile and fixed wireless internet provision. We examine how this could expand broadband access to areas where there is none, increase the choice of access options for users or lower the cost of access – especially for areas with limited broadband coverage such as rural areas.

Dynamic Spectrum Access

We are entering an era of an ever increasing appetite for broadband consumption with exabytes[a] consumed per month almost doubling every two years mainly driven by internet video services. Many operators talk about a spectrum-crunch and the need for more spectrum to deal with this broadband deluge.

However, when you analyze the usage of spectrum allocated to operators, most of its usage is concentrated around urban areas, with rural areas often having an abundance of spectrum available. This is particularly evident in South Africa and other African countries. So in essence, high-value, high-demand spectrum is full of "white spaces" and the perceived 'spectrum shortage' is in fact an artefact of the prevailing mode of spectrum management, of granting exclusive-use licenses to particular frequencies. This licensing regime does not effectively and efficiently use spectrum allocated to operators and limits the ability to apply different pricing models for low-income regions as cost structures are applied at a national level.

We can learn a lot from the success of Wi-Fi which carries 69 percent of the global internet traffic, mostly in the 2.4 gigahertz (GHz) radio frequency band that only has 80 megahertz (MHz) of spectrum compared to 270 megahertz (MHz) of spectrum in the 1800 and 2100 megahertz (MHz) radio frequency bands combined and available currently for third generation (3G) and Long-Term

3 http://www.cisco.com/c/dam/assets/sol/sp/vni/forecast_highlights_mobile/index.html#~Country
4 http://www.researchictafrica.net/pricing/ramp_1gb.php

Evolution (LTE) in South Africa (excluding the 2300 megahertz (MHz) radio frequency band used by Telkom). This has been achieved by using rule-based spectrum access in license-exempt bands where a set of strict power rules and smart collision avoidance techniques have allowed Wi-Fi to co-exist even when interference occurs.

Wi-Fi has confounded the typical Coasian[b] view of the radio spectrum which speaks of the tragedy of the commons in which overexploitation leads to the emergence of a low productivity equilibrium or possibly even a collapse of the usability of the entire spectrum resource. It also shows that the property-rights metaphor for spectrum use is misleading as it ignores the fact that the capacity of spectrum is a function of technology. Indeed, were it possible for land to undergo the same improvements in use as spectrum then it would be possible many times over to "use of a piece of land simultaneously for growing wheat and as a parking lot". The volume of innovation and investment taking place would appear to rule out a resource system in danger of imminent collapse as new radio innovations come to market that allow for ever more users and uses to non-destructively share the same band.

The success of Wi-Fi using rule-based radio frequency spectrum access leads us directly into a growing movement to allow portions of spectrum to be used dynamically in regions or at times that it is not used – a concept commonly known as Dynamic Spectrum Access (DSA). DSA uses technologies such as cognitive radios that can carry out spectrum sensing or geo-location spectrum databases to find portions of unused spectrum. Wi-Fi already has some aspects of DSA due to its ability to avoid interference with other co-users of the spectrum. Access is typically granted on a license-exempt or light-licensing basis. The best current example of DSA is Television White Space (TVWS)[c], which makes use of geo-location spectrum databases to find unused spectrum in the TV bands.

Other techniques such as Licence Shared Access (LSA) are also being explored to share spectrum that is currently allocated to incumbents that only use this spectrum in specific locations. However LSA techniques are typically used to provide exclusive access to operators unlike DSA where many secondary users can make use of primary user spectrum, only guaranteeing interference-free operation for primary users and not for secondary users. In the United States of America (USA), LSA is being used to share the 2.3 GHz band, mostly used for coastal radar and in the United Kingdom (UK), the 3.6 – 4.2 GHz LSA is being used to share bands for defence, emergency services and broadcasting services.

Sharing spectrum with DSA or LSA allows spectrum to be used far more efficiently and effectively and allows more small operators into the market, who use this spectrum in areas where it is not used. DSA technologies such as TVWS are more likely to open up more competition as it allows many smaller operators into the market to share unused spectrum and is more akin to the model of Wi-Fi. Many of the early standards in TVWS such as IEEE802.11af[d] are essentially an extension of the Wi-Fi standard with the addition of the requirements for a geo-location spectrum database. Due to lower spectrum costs when sharing spectrum in specific regions, these smaller operators can provide better priced access solutions in these areas. However, regulation has not caught up with technology and is still trapped in exclusive use access models based on early 1900s models of protecting wireless telegraphy from interference. Regulation would need to evolve from protecting the right to exclusive use of spectrum to the right to protection from interference.

There are a number of success stories to reflect on both in Wi-Fi access and in the emerging area of

DSA. In South Africa, public Wi-Fi services such as Tshwane Wi-Fi have lowered the cost of access for citizens of Tshwane – providing 500 megabytes (MB) of free internet per day. In small towns in South Africa such as Philipstown in the Karoo, where there are no broadband services available, Wireless Internet Service Providers (WISPs) have provided broadband fixed wireless services at 58 percent of the cost of cellular operator's pre-paid data services for 10 gigabytes (GB) of data[5]. In the rural community Mankosi in the Eastern Cape. Wi-Fi Mesh was used to create a telephone and internet co-operative. Local calls are free and calls to other networks cost half of what they would on those other networks. Data costs a tenth of the market price[6].

There have also been a number of successful TV white space trials in South Africa and the rest of Africa that have demonstrated that it is possible to provide broadband internet services in rural areas with abundant Ultra High Frequency (UHF) spectrum available such as the trial in Limpopo and Zomba, Malawi connecting schools to a university. Trials have also carried out in urban areas where there are many TV channels operating such as the trial in Cape Town, South Africa[7]. The CSIR is carrying out research and development on technologies and algorithms that will support TVWS services and DSA technologies in general in South Africa, and the rest of Africa. These technologies include the CSIR Geo-Location Spectrum database that has been approved by Ofcom (The Communication Regulator in the United Kingdom)[8] as well as a White Space Mesh Node that adds TVWS capability to the High Performance Mesh Node (HPN) used to connect rural schools in South Africa. We are also in the process of assisting with the development of TVWS regulation in South Africa, the Independent Communications Authority of South Africa (ICASA) has completed the process of a call for inputs from industry and published the results of these inputs[9]. This will be followed with the development of draft regulation for the operation of TVWS services.

Recommendations

Our recommendations are the following:

- Continue to support the process to allow new spectrum management regimes such as Dynamic Spectrum Access (e.g. TVWS) on a license-exempt or occasionally light-license and License Shared Access basis in appropriate cases.
- Support the entrants of new operators into the market, including WISPs, community networks, and co-operatives – especially those that can serve under-serviced areas - ensuring that they have access to appropriate spectrum at an affordable cost.
- Expand the concept of spectrum sharing to infrastructure sharing and support open access models for all infrastructure such utility poles, ducts and backhaul fibre as well as local loop fibre/copper.
- Connection of open access telecommunications infrastructure to hubs such as public facilities (schools, libraries and clinics) in poorly serviced areas that new operators can use to lower the cost of their backhaul connectivity.

We believe that Dynamic Spectrum Access will amplify the growing success of Wi-Fi, provide new

5 http://www.albieswireless.co.za/
6 http://zenzeleni.net/
7 http://spectrum.ieee.org/telecom/internet/malawi-and-south-africa-pioneer-unused-tv-frequencies-for-rural-broadband
8 http://whitespaces.meraka.csir.co.za
9 https://www.greengazette.co.za/documents/national-gazette-40078-of-17-june-2016-vol-612_20160617-GGN-40078.pdf

opportunities for current operators, bring new operators into the market and help lower the costs of access and allow us to achieve targets we have set in SA Connect.

[a]Exabytes (EB) is a multiple of the unit byte for digital information. The prefix exa indicates multiplication by the sixth power of 1000 in the International System of Units.
1 EB = 10006 bytes = 1018 bytes = 1000000000000000000 B = 1000 petabytes = 1 millionterabytes = 1 billiongigabytes.

[b]Ronald Coase developed his theorem when considering the regulation of radio frequencies. Competing radio stations could use the same frequencies and would therefore interfere with each other's broadcasts. The problem faced by regulators was how to eliminate interference and allocate frequencies to radio stations efficiently. What Coase proposed in 1959 was that as long as property rights in these frequencies were well defined, it ultimately did not matter if adjacent radio stations interfered with each other by broadcasting in the same frequency band.

[c]In telecommunications, white spaces refer to frequencies allocated to a broadcasting service but not used locally.

[d]IEEE 802.11af, also referred to as White-Fi and Super Wi-Fi is a wireless computer networking standard in the 802.11 family, that allows wireless local area network (WLAN) operation in TV white space spectrum in the Very High Frequency (VHF) and Ultra High Frequency (UHF) bands between 54 and 790 mega hertz (MHz).