The broadband divide: Where is the digital highway heading?

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"Broadband is no longer a luxury… it is a core infra-structure of the modern economy. Those who have it will prosper, and those who don't will fall further behind." This is the unequivocal opinion of Dr Hamadoun Touré, Secretary-General of the International Telecommunication Union (ITU).

It is an opinion shared by many developed countries in the world. Finland is a great leader in this regard, and is advocating for the establishment of broadband as a basic legal right. In the USA, President Barak Obama launched his National Wireless Initiative in 2010. The message is clear: advanced connectivity will deliver major economic benefits everywhere.

The difference between communities with a strong information and communication technology (ICT) infrastructure and those with a weak ICT infrastructure is commonly referred to as the "digital divide". However, it is not just emerging economies like South Africa that have a digital divide. A 2010 study for the Federal Communications Commission (FCC) in the USA by the Social Science Research Council found that "low-income communities are marginalised without access to broadband – and they know it".

What is broadband?

According to the FCC, "broadband" – or high-speed internet access – allows users to access the internet and internet-related services at significantly higher speeds than those available through dial-up internet access services. Broadband speeds vary significantly, depending on the particular type and level of service ordered, and may range from as low as 200 kbps to 30 gigabits per second (Gbps).

The benefits of broadband

The South African government also realised the benefits of broadband with the publication of the National Broadband Policy by the Minister of Communications in July 2010. The vision of this policy is to ensure universal access to broadband by 2019, ensuring that South Africans are able to access broadband either individually, or as a household subscribe to a broadband service, or are able to access a broadband service directly or indirectly at a private or public access point. Broadband is recognised as a strategic tool in the building of an information economy and society. Extensive international studies have been performed on the benefits of investing in broadband infrastructure. In every such study, broadband has demonstrated the ability to deliver substantial economic growth, increased employment and vast societal benefits.

The potential benefits will contribute positively to improving the lives of many South African households, for example, by improving communication, and providing access to services, employment and business opportunities.

The impact of broadband can be recognised by the fact that it addresses each one of the eight Millennium Development Goals, which were adopted by the United Nations in 2000 to guide the world's efforts to alleviate extreme poverty by 2015. As such, broadband plays a role in the following:

- Eradicating extreme poverty and hunger
- Achieving universal primary education
- Promoting gender equality and empowering women
- Reducing child mortality
- Improving maternal health
- Combatting HIV/Aids, malaria and other diseases
- Ensuring environmental sustain-ability
- Developing a global partnership for development

ICT RDI Roadmap

The South African Department of Science and Technology (DST)

"Today, you can tell the rich from the poor by the quality of their internet connections, both within countries and between them."

– Dr Shashi Tharoor, ITU Broadband Commissioner

has developed an ICT Research Development and Innovation (RDI) Roadmap to put South Africa on the road to gaining the digital advantage in order to promote economic growth.

The roadmap comprises six key clusters of opportunity that represent areas of significant and attractive market need, to which researchers and policy-makers can feasibly, and with differentiation, respond by building on existing capacity in order to impact on the dimensions of wealth, society and national advantage. These clusters are broadband infrastructure and services, development, sustainability and the environment, grand science, industry applications, and the service economy. Each of these clusters has a number of associated market opportunities, as illustrated in Figure 1.

Making an impact through research

Prof Sunil Maharaj, Head of both the Department of Electrical, Electronic and Computer Engineering at the University of Pretoria and the SENTECH Chair in Broadband Wireless Multimedia Communications (BWMC), delivered an expert lecture at the University of Pretoria on 21 August 2013, entitled 'The broadband divide: where is the digital highway going?'

According to Prof Maharaj, there were around 5 000 analogue mobile subscribers in 1980. With the role that the Global System for Mobile Communications (GSM) started to play in digital mobile in 1988, it is predicted that by the end of 2013, there will be approximately seven billion connections in the world. With such spectacular growth in the wireless communications industry, the next challenge is the provision of greater throughput via broadband connections that are both pervasive and affordable.

Today broadband wireless technology is largely based on orthogonal frequency division multiplexing (OFDM) technology. Current challenges in this area include the development of "green radios" due to increased power consumption, the opportunity for spectrum sensing and cognitive radio, the digital divide and the radio frequency spectrum regulatory landscape, and innovation in software applications and localisation.

These challenges are driving the work of the SENTECH Chair in BWMC at the University of Pretoria. Its mission is to participate in cutting-edge research activities in the field of broadband wireless communications, and to deliver world-class research and educational outputs for the benefit of SENTECH, the University of Pretoria, other industry sponsors and South Africa in general.

A number of innovative research projects are currently underway, including the following:

MIMO channel modelling for indoor wireless communication

This research investigates multiple-input/multiple-output (MIMO) channel modelling for a wideband indoor environment. The theoretical basis of geometric modelling for a typical indoor environment is examined, and a space-time model is formulated. The transmit-and-receive-antenna correlation is then separated and

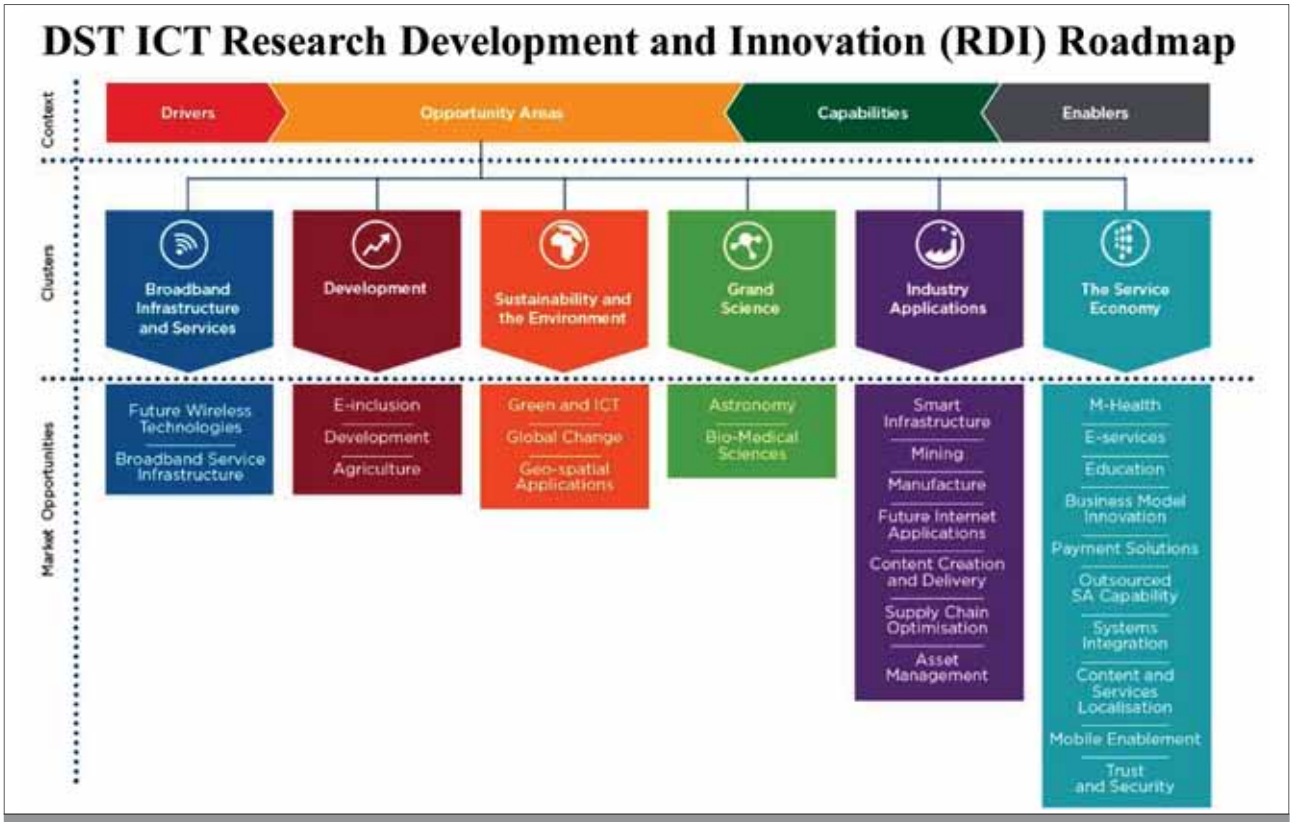

Figure 1: DST ICT Research and Development Innovation (RDI) Roadmap.

Students in the SENTECH Chair in Broadband Wireless Multimedia Communications participate in forefront research activities in this field.

expressed in terms of antenna element spacing, the scattering parameter, mean angle of arrival and the number of antenna elements employed. These parameters are used to analyse their effect on the capacity for the chosen environment.

Cognitive radio performance optimisation through spectrum availability prediction

The FCC has predicted that a spectrum shortage may occur in the near future under the current regulatory environment. This impending spectrum shortage is in part due to a rapidly increasing demand for wireless services and inefficient usage of currently licensed bands.

A new paradigm pertaining to wireless spectrum allocation, known as cognitive radio (CR), has been proposed as a potential solution to this problem. This project seeks to contribute to research in the field of CR through an investigation into the effect that a primary user channel occupancy model will have on the performance of a secondary user in a cognitive radio network. This model is important, since it provides secondary users with a basis for channel switching and future channel allocations.

An offset modulation method used to control the PAPR of an OFDM transmission

Orthogonal frequency division multiplexing (OFDM) has become a very popular method for high data rate communication. However, it is well known that OFDM is plagued by a large peak-to-average power ration (PAPR) problem.

One of the results of a high PAPR is an inefficient transmitter, which is not desirable. Various methods have been recommended to reduce the PAPR of an OFDM transmission. However, all these methods have a number of drawbacks. This research develops a novel method called offset modulation (OM-OFDM) to control the PAPR of an OFDM signal. The proposed OM-OFDM method does not suffer from a number of the drawbacks experienced by current methods in the field. The BWMC Group has filed a patent for this methodology.

By using the newly applied power performance decision metric, the OM-OFDM method is shown to offer significant performance gains when compared to existing constant envelope (CE)-OFDM (and traditional OFDM transmission methods).

The future of broadband

In his expert lecture, Prof Maharaj considered whether the end of the road is near in terms of increasing throughput, and posed the question: What will be the next wave? The answer, according to Prof Maharaj, lies in the development of millimetre-Wave (mm-Wave) communications, which could possibly lead to next-generation (5G or 6G) Millimetre Mobile Broadband (MMB). Millimetre-Wave lies at the high end of the microwave frequencies, and has a frequency of 30 GHz ~ 300 GHz. It will enable scientists to explore a new spectrum for mobile broadband communication. Some of the current applications of mm-Wave include radio astronomy, wireless backhauls, intersatellite links, high-resolution radar and security screening.

Through the innovative and internationally relevant research in the field of broadband wireless multimedia communications, Prof Maharaj hopes to contribute to bridging the digital divide, and ensure that the broadband divide does not become the next evil in our society: that our citizens and communities are not disadvantaged due to their lack of access to a high-speed digital connection.