NATIONAL SCIENCE AND TECHNOLOGY FORUM (NSTF)

pro*SET* (PROFESSIONALS IN SCIENCE, ENGINEERING AND TECHNOLOGY)

PROCEEDINGS OF DISCUSSION FORUM ON

INTERNET OF THINGS TECHNOLOGIES AND 5G ROLL-OUT

Date: 23 November 2020
Time: 13:30 to 15:30
Venue: Zoom meeting

WELCOME (MS JANSIE NIEHAUS, EXECUTIVE DIRECTOR, NSTF)

Ms Niehaus welcomed everyone to the discussion forum.

The purpose of the forum was to inform people about the new technologies (Internet of Things (IoT)) and 5G (or fifth generation of cellular networks) and their potential, and equip them in terms of the controversies and debates around these kinds of technologies, the roll-out of 5G and beyond. The NSTF discussion forums on the Fourth Industrial Revolution (4IR) and advanced manufacturing and automation showcased numerous presenters who shared their knowledge and insights. It was important to debunk the misconceptions about 5G and related infrastructure that were to some extent controversial and believed to be detrimental to people's wellbeing. While China was already rolling-out 6G, South Africa lagged behind in terms of accessibility to efficient internet connectivity, which was absolutely crucial in order for the country to be able to progress despite the limitations.

PRESENTATIONS

Mr Sean Laval, Executive Director, Solutions and Innovations, SqwidNET

The presentation aimed to provide a better understanding of selected IoT network technologies that are available worldwide as well as an overview of some of the key drivers behind each of them.

The data requirements of IoT devices are uplink-intensive and most of them require less than 1Megabyte (MB) of data per month, yet people consume data in a downlink-intensive way that uses a lot more the 1MB of data. The main network technologies that are contending for IoT traffic currently include:

- Traditional cellular based networks (such as 3G, 4G and some higher-bandwidth 5G technologies), which require high data powered devices that provide national coverage and have high reliability.
- Long-Term Evolution for Machines, known as LTE-M, which uses 1.4 Megahertz (MHz) of spectrum, has slightly lower power consumption than some of the traditional Long-Term Evolution (LTE) protocols and provides national coverage.
- Narrowband Internet of Things (NB-IoT), which is low-power wide-area network technology used by most mobile operators. Typical applications include electricity meters or control applications in industry that are usually deployed in urban areas.
- LoRaWAN (long range wide area network), which allows people to set up wide area networks and is typically used in localised agricultural or industrial deployments that manage their own network infrastructure.
- Sigfox, which is built around national deployment and a global network for small messages (low-end tracking) to accommodate the tens of billions of devices projected to come into the IoT world.

Until recently, cellular networks were used to deploy IoT solutions nationally. Although cellular networks are suitable for a lot of applications that require higher bandwidth, they are power intensive, not designed to provide years of battery life and costly. Other technology that is commonly used includes WiFi, which has high power consumption, and good short-range low-power technology such as

Bluetooth. Low-power wide-area (LPWA) networks have become available recently and provide national coverage similar to cellular networks but with low power consumption, opening up a lot of applications in IoT that were previously not possible or feasible. One of the drivers for the emergence of LPWA networks is accessibility to Cloud infrastructure. All LPWA technologies are low-cost, low- power, long-range as well as reliable and secure. Some of the main technologies in the LPWA space include NB-IoT, Sigfox and LoRaWAN and these are expected to become the cornerstone of IoT technologies in coming years.

There are two main categories of networks: synchronous networks and asynchronous networks. Synchronous networks (such as cellular networks) establish a connection with a device and have scheduled communication with that device, and provide high quality service, high data and high bandwidth. Their drawbacks include higher complexity on the side of the devices and the licence spectrum requirement, both of which contribute to high cost and high power consumption. Asynchronous networks do not need to pair with a device as a sent message is picked up by all the base stations in the vicinity. It is important to deploy a network in an asynchronous format when using unlicensed spectrum where a high quality of service is required. The complexity is abstracted from the device and sits with the network. The device can be simpler and power consumption is fully controlled. Asynchronous networks are immune to interference, malicious jamming in particular, and are therefore sought after in the security sector.

The NB-IoT standard originated in 2016 and has now been brought into the 5G roadmap. Although it aims to facilitate lower power consumption it still requires relatively high power, but is efficient in terms of how it uses licence spectrum. An operator with licensed spectrum can deploy a NB-IoT network in the following ways: standalone (re-farming 2G spectrum), in-band (using a slice within an existing LTE band and guard band (between the chunks of LTE spectrum). Most operators see NB-IoT as communication protocol of the future, even though it has some problems. One of the main problems is that it can be difficult to justify using 200 Kilohertz (kHz) of spectrum for something that does not generate as much revenue as core data traffic from traditional users in a spectrum starved environment. Another issue is that the standard is not compatible across hardware providers and this has slowed down deployment in some operators around the world.

However, 5G will not facilitate the vast majority of IoT connections anticipated in the future. This is why proprietary networks such as Sigfox, which brands itself as 0G and is present in over 70 countries around the world, have emerged. A Sigfox network works in the heavily regulated unlicensed spectrum and uses only 192 kHz of the 200 kHz channel. Each message is sent at 100 hertz (Hz). Sigfox is built around ultra-narrow band modulation schemes. Many messages can be fitted into the channel at once. The narrower the spectrum used to transmit a message, the higher the power spectral density of the message. Sigfox is built on the following pillars: ultra-narrow band, time diversity, frequency diversity and spatial diversity. The network is deployed such that each message sent by a device goes to at least three base stations simultaneously. This ensures that there is a very low chance of interference and allows Sigfox to deliver a high quality of service.

Sigfox in South Africa is run through SqwidNet, which currently deploys over 1500 commercially managed base stations, each with full redundant communication. Most of the devices are sleeping most of the time. The device itself can determine when an event has occurred, then wake up and send. This means that there are many years of battery life. Even though the base stations are cutting- edge software-defined cognitive radios, most of the intelligent decisions happen at the Cloud. One of the benefits of these proprietary networks is that they are not Subscriber Identity Module (SIM) based and this makes the management much simpler. From the Cloud infrastructure, a message is sent wherever it needs to go.

NB-IoT and Sigfox have various pros and cons, but both have taken their place in the IoT spectrum and will be used for many years to come.

Q&A

Debbie Schultz: What is meant by 5G 'standard' in plain language?

Response, Sean Laval: The standard is about standardisation and ratified by the International Telecommunication Union (ITU) that oversees network standards globally. The ITU decides what is included in the 5G (or other G) standard. A series of standards is built into the 5G standard. Some of them work on 28 Gigahertz (GHz) and others are very high bandwidth communication protocols, but other things can be brought in. They have looked at NB-IoT and LTE-M to serve a certain part of the 5G standard. It is important that they all talk to the same network core once they are ratified by the ITU. Once there is standardisation, industry can invest heavily in infrastructure knowing that there is compatibility among vendors. This is the ITU's task. Spectrum allocation facilitates it.

Debbie Schultz: Why is it important to have low power?

Response, Sean Laval: Low power is important for IoT devices because most of them are not readily connected to power sources. IoT is all about getting information for the physical world which does not have a readily available power source. Low power is essential when monitoring assets that move around and don't have a readily available power source, such as a trailer when disconnected from a truck. A courier company in Germany is able to monitor and track over 250 000 of their steel containers that are used to transport boxes to numerous distribution points across the country using the Sigfox network. Another example is water meters where there is no available power supply and installation is costly. In addition, it is necessary to get multiple years of service from the meters before having to change batteries in order to justify the return on investment.

Busisiwe Alant: What is meant by 93% national coverage in terms of online education provision to rural areas?

Response, Sean Laval: 93% coverage refers to the percentage of the South African population that has network coverage. This is mainly in urban or semi-suburban areas. The Sigfox network can facilitate network coverage in rural areas in a way that some of the traditional networks cannot. Sigfox has partnered with the University of Johannesburg (UJ) on one of their projects in a very remote village in Limpopo where there was no cellular coverage. Sigfox installed a base station using solar power from the top of a hill, backhauling to a cellular network. This enabled IoT connectivity that was previously unavailable and opened up a range of opportunities for the project. An example of a commercial service is that Sigfox has covered most of the Kruger National Park using its solar powered base stations. Sigfox has shown to be a versatile network.

Dhevan Pillay: What are the monthly costs of communication per device, and of a typical device using Sigfox?

Response, Sean Laval: The cost is based on volume and how many messages are needed per day. Sigfox has three connectivity tiers: 140, 70 or 2 messages per day. Costs range from around R200 to around R15 per year, depending on the contract duration and the number of messages and devices required. Sigfox is built to support the scale of IoT devices and is not meant to compete with the cellular networks that have higher data requirements. Sigfox is the right technology and is cost effective in situations that do not need more than 140 messages per day.

Dr Fesseha Mekuria Chief Research Scientist, Council for Scientific and Industrial Research (CSIR)

The CSIR is a multi-disciplinary research institution comprising a number of technology sectors positioned to drive South Africa in industrialisation, converging around the 4IR. The institution recently celebrated its 75th anniversary and has updated its vision and mission to focus on its role in accelerating socio-economic prosperity in South Africa through leading innovations, collaboration and localisation of technologies while providing knowledge solutions for the inclusive and sustainable advancement of industry and society.

The generations of digital wireless/mobile Information Communication Technology (ICT) technology

standards started in the 1980s with mobile technology on analogue devices that only provided basic voice services. The second and third generations (2G and 3G) followed from around 1985, providing more data communication, multi-media and text information over a wireless/mobile interface. Due to popular demand, more and more data bandwidth was added to the mobile communication sector. The fourth generation (4G) provided more internet protocol (IP) based networks and true mobile broadband using smart phones. The fifth generation (5G) further increases bandwidth per user, but the networks are more complex and more difficult to build, and it involves a group of standards instead of a single standard. Currently, sixth generation (6G) technologies are being developed that promote new ways of optimising networks and make more broadband more widely available.

The group of 5G technology standards supports the different use cases defined in the technology standards. These are: Enhanced Mobile Broadband, Ultra-Low Latency and Reliable Networks, and Massive Machine Type Communications (MTC). However, these technologies only support urban areas and not rural and under-served areas. An affordable broadband standard (5G range extension) for digital inclusion of under-served areas has been defined in order to overcome this problem. The connection between Artificial Intelligence (AI) and the new 5G networks has also been defined, and the CSIR has developed expertise in the spectrum toolboxes and aims to share this expertise. Use cases for medical care, transportation, entertainment, energy and logistics have been added to the standards.

Successful application of emerging new technologies would require cooperation between regulators, industry, the CSIR and government in public-private partnerships in order to develop relevant social values and the economy, ensure safer cities, create a thriving ecosystem and improve quality of life for all. The CSIR is building a technology test bed for 5G that can be used by young innovators and university researchers to develop more innovative 5G use cases, new applications and Smart Industry Verticals. The regulator will be required to provide enough activity for the spectrum and testing of the technologies so new industries can be developed. Several international partners support the CSIR test bed, which although still under development, is already being used to test a number of applications.

More spectrum needs to be allocated to 5G technologies. To this end, the smart spectrum toolboxes developed by the CSIR need to be utilised, there will have to be collaboration with operators and industry, and the 5G test trials in South Africa should be extended to include the CSIR test bed in order to be able to do control tests of the 5G applications. To bridge the rural and urban digital divide with affordable and sustainable rural connectivity, the CSIR has been working on technology called TV White Spaces and has developed a network roll-out for sustainable connectivity, and together with the United Nations Development Programme (UNDP), is supporting Small, Medium and Micro Enterprises (SMMEs) and local entrepreneurs to provide broadband internet services to rural under-served communities using technology developed at the CSIR. The CSIR's Smart Spectrum Toolboxes received the NSTF prestigious award. The CSIR is also supporting SMMEs with a sustainable connectivity ecosystem, ensuring co-creation with local communities and continuous innovation using green energy to power the networks and developing value-added services.

A convergence of numerous 5G technology skillsets contribute to the 4IR. The CSIR supports the regulatory body, Independent Communications Authority of South Africa (ICASA), to develop enabling policy, standards and regulation to support this. The most important use case for emerging digital technologies in the 4IR is the effective, efficient utilisation of natural and technological resources for the envisaged Smart Cities. However, a relevancy check needs to be done to ensure the ethical use of emerging digital technology. Young innovators are challenged to come up with ethical and relevant use cases using the emerging digital technologies. The CSIR supports such innovation.

The CSIR together with industry developed a White Paper Report on how 5G technologies can be utilised in use cases in Africa. Given that 5G is a global phenomenon, numerous 5G forums take place around the world. The CSIR and ICASA participate in these and support a variety of activities in this regard.
Emerging digital technology skillsets include:

- Emerging technology expert Science, Engineering and Technology (SET) skills
- Digital society and user skills
- Regulatory, policy and business creation skills.

It is anticipated that by 2030 5G would have provided numerous benefits for society and industry that are of substantial importance to developing countries in particular, including job creation and Gross Domestic Product (GDP) growth.

In conclusion:

- The commercial roll-out of 5G is taking place in South Africa and other countries.
- The future of 5G and the implications of 6G were discussed at a recent international conference in which the CSIR participated
- IoT and 5G bring with them many technologies that will support the 4IR vision
- 5G should be used to transform the 4IR into a solutions revolution and solve challenges relating to the United Nations' Sustainable Development Goals (SDGs)
- Technical regulations, business models, policy and ethics relating to 5G and its use need to be put in place.
- 5G is a global standard that presents immense opportunities for realising the 4IR and as such requires international collaboration as well as collaboration within the country between industry, regulators, government and society.

Q&A

Debbie Schultz: If each standard is meant to ensure standardisation, reduced cost, improved efficiency and so on, how much is changed between each phase of the standard (for example from 1G to 5G)? Is it a minor change, a mere addition, or an actual replacement? If it is a replacement, would it not defeat some of the purpose of having a standard?

Response, Fesseha Mekuria: Moving from one generation to the next is forced upon us by the technology. 1G technologies (analogue) cannot provide coverage to as many people as 2G technologies, which is digital and provides improved efficiency. The continuous demand for improved efficiency and more services by increasing numbers of people drives the development of technology. The new technology must be defined and standards are developed. This is how one generation supersedes another.

Busisiwe Alant: How can Higher Education Institutions (HEIs) use emerging digital technologies to drive strategy and innovation?

Response, Fesseha Mekuria: HEIs need to introduce skillsets development and be willing to revise their curricula to be applicable to the new emerging technologies. This should be accelerated to keep up with the new developments in technology. HEIs also need to support young innovators and SMMEs in technology development. The universities' Technology Transfer Offices should encourage universities to apply the information given in the presentations and discussions at this forum and develop new curricula or modules in the existing curricula in order to accelerate the development of skillsets by graduates. IoT and 5G offer many opportunities for graduates to innovate and develop patents. Universities are encouraged to take up this challenge.

Noer Rylands: A core industry with the name 'Edge Computing' was mentioned in one of the slides. Is this industry or technology cluster related to 'quantum computing' or is it something different?

Response, Fesseha Mekuria: It is something different. Edge Computing has to do with making sure that the competition is not centralised so that the rural population (for example) has access to some of the services on offer. It is about bringing computation to the service and customer level. Quantum computing is part of 6G where it will be required for AI systems as these are computationally intensive.

Linoh Magagula: Should wireless communication technologies come before other developments (industrialisation, infrastructure, etc.) or after the developments? We see in the first world countries that the 5G and 6G technologies are coming after the developments have been achieved.

Response, Fesseha Mekuria: This is a 'chicken and egg' situation because wireless communication will

support the infrastructure roll-out. One of the reasons why emerging economies are dependent on wireless technologies is that they do not have wire-line technology roll-outs that one sees in urban areas. Many African countries do not have any wire-line communications and are using wireless communication more and more. We need to rely on wireless communications to communicate between the infrastructure and people, transportation mechanisms and so on. It is important to build wireless infrastructure together with and at the same time as basic infrastructure, such as roads and water and electricity supply.

Wilna Eksteen: Can we have more information about the hardware, such as transmission towers and the difference between 5G hardware and the types of waves it uses, and about why some people are afraid of 5G?

Response, Fesseha Mekuria: I do not have all the information about these issues. I think that people are afraid of 5G because the frequency is increased to such an extent (above 6GHz) that it moves into the microwave areas and we know about the effects of microwaves on humans and nature. We know that the mobile operator, MTN, built transmission towers that used 24GHz for 5G. There are international regulations addressing the use of those spectrum areas and the location of towers. ICASA is aware of this regulation and it needs to enforce it on mobile operators. The CSIR and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) websites provide helpful information about this matter.

Mandla Dlamini: Why are all these networks not available in townships and rural areas?

Response, Fesseha Mekuria: They will come to those areas, but first it will be necessary to develop SMMEs in rural areas that will provide broadband internet in those areas using cheap technologies because people cannot pay for the data that is offered by mobile network operators. The CSIR is working on providing sustainable connectivity through developing alternative technologies and sharing spectrum with TV broadcasting stations. Once the rural SMMEs are well-established they will be able to provide 5G to rural areas in collaboration with mobile network operators. It is necessary to build and strengthen the economy in rural areas in order to meet the demands of the mobile network operators and be able to provide 5G as well as 6G. The CSIR would like mobile network operators to support the efforts to provide internet connectivity in rural areas and townships.

In its drive towards sustainable connectivity, the CSIR would provide the network and the possibilities of Edge Computing in rural areas, and would like to see communities (and schools) developing their own local content and value added services.

Response, Sean Laval: Sigfox covers some rural areas, but its coverage is built around population (according to the last census data). There will be sparsely populated areas that are not covered and this is due to lack of demand and other reasons explained by Dr Mekuria. It is important to know that it can be put in rural areas fairly simply. We do this on a case to case basis. Most townships around urban areas are covered. We have seen innovative use cases in townships, such as fire monitoring services (using sensors) that provide the ability for residents to insure their goods. One of the drivers for Sigfox to expand in rural areas in an economically sustainable manner has to do with agricultural requirements in the 4IR. We are seeing good business cases around using technology to farm crops more efficiently and applications for tracking livestock.

Busisiwe Alant: Would Mr Laval elaborate on the project that Sigfox is involved in with UJ?

Response, Sean Laval: About three years ago, UJ partner with a company that sponsored solar equipment (a borehole and bakery) in a small village in Limpopo that did not have municipal services. However, there was no ability to monitor the solar borehole and bakery, and UJ needed intelligent insights in order to make the project sustainable. Through monitoring the variable speed drive of the solar borehole power through the Sigfox network some anomalies were detected and the problems were able to be resolved before the borehole pump was damaged. The borehole produces water for sanitation and drinking, as well as to spray crops, enhancing the lives of people with relatively low investment.
The link to the project on UJ's website will be shared with the NSTF.

CLOSING

Ms Niehaus informed participants about the pro*SET* project called the STEMulator, which is an online exploratorium for young people to find out about how things work, the various sciences and careers they can follow. The NSTF needed to find ways to effectively disseminate the STEMulator in order to make the project accessible to learners, particularly those in rural areas. She requested NSTF members to propose possible solutions to the problem and appealed to them to contribute content (particularity pictorial and animated content) to the STEMulator project.

Ms Niehaus thanked Dr Mekuria and Mr Laval for their interesting and informative presentations and responses to questions, as well as all the participants for their contributions to the discussions.

ANNEXURE A: ATTENDANCE LIST

Name	Surname	Organisation
Sherrie	Donaldson	African Innovators
Madimetja	Lephoto	Alectrona Consulting (Pty) Ltd
Johan	van Heerden	Altron
Mandla	Dlamini	Ambitious IT Technologies
Thubalakhe	Masango	Cape Peninsula University of Technology (CPUT)
Mihlali	Hobo	Council for Geoscience (CGS)
Ndivhuwo	Mukosi	CGS
Emmanuel	Sakala	CGS
John	Davies	Consultant
Fisseha	Mekuria	Council for Scientific and Industrial Research (CSIR)
Beaulla	Mathebula	Department of Science and Innovation (DSI)
Piet	De Klerk	Engineering Consultant
Tiffany	Techow	Executive Research Associates
Zakhele	Mathebula	Gauteng Department of Education
Marinus	Rooyen	Jendamark
Kobus	Fourie	JF Consulting
Carol	Annandale	Lasec Education
Teddy	Mnisi	Limpopo Department of Agriculture and Rural Development
Charlotte	Mohlabi	LDARD
Sanari Chalin	Moriri	LDARD
Dhevan	Pillay	LTM Energy
Banu	Sankaran	Mbilwi Secondary school
Stephanie	De Beer	Mills and Otten Environmental Consultants
Michael	Woodhall	MineRP
Kondwani	Banda	Council for Mineral Technology (Mintek)
Ndabenhle	Sosibo	Mintek
Petrus	van Staden	Mintek
Philasande	Bongo	Mvelaphi Yethu (Pty) Ltd
Aadil	Essop	National Metrology Institute of South Africa (NMISA)
Eugene	Golovins	NMISA
Abongile	Jijana	NMISA
Pritesh	Jivan	NMISA
Bongani	Mabunda	NMISA
Linoh	Magagula	NMISA
Gilbert	Groenewald	North-West University (NWU)
Noer	Rylands	Passenger Rail Agency South Africa (PRASA)
Sephela	Thema	Sibanye Stillwater
Shafieqa	Ismail	S.Ismail Consulting Electrical Engineers CC
Pascal	Motsoasele	South African Institute of Electrical Engineers (SAIEE)

Name	Surname	Organisation
Barry	Bredenkamp	South African National Energy Development Institute (Sanedi)
Sean	Laval	SqwidNet
Wouter	Klapwijk	Stellenbosch University (SU)
Marie	Theron	SU
Frederik	van der Merwe	SU
Richard	Gundersen	STEMulator NPC
Zohreh	Fakhraei	Sound Mining Solution
Mehdi	Nasiri	Sound Mining Solution
John	Werth	The African Association of Zoos and Aquaria (PAAZA)
Natalie	le Roux	University of Cape Town (UCT)
Messai	Mamo	University of Johannesburg (UJ)
Busisiwe	Alant	University of KwaZulu-Natal (UKZN)
Walter	Meyer	University of Pretoria (UP)
André	Broekman	UP
Kerstin	Kruger	UP
Michelle	Schroder	UP
Paul	Kogeda	University of the Free State (UFS)
Donald	Kubayi	University of South Africa (Unisa)
David	Everatt	University of the Witwatersrand
Halfdan	Lynge	University of the Witwatersrand
Sihe	Nhleko	University of the Witwatersrand
Sarel	Havenga	Vaal University of Technology (VUT)
Lance	Baum	Vault Group
Linda	Crawford	
Simone	Naicker	
Tieho	Tsiane	
Nqobile	Jiyane	
Staff and Service Providers		
Name	**Surname**	**Organisation**
Heather	Erasmus	Write Connection CC
Jane	Mokgwatshane	NSTF
Debbie	Schultz	Alphabet Soup
Pertunia	Ndlovu	NSTF
Lucky	Mokhosi	NSTF
Mosima	Mabitsela	NSTF
Felicia	Likhethe	NSTF
Gabriela	Mankune	NSTF
Wilna	Eksteen	NSTF
Jansie	Niehaus	NSTF
Matome	Mphela	NSTF

ANNEXURE B: ACRONYMS

4IR	Fourth Industrial Revolution
5G	fifth generation of cellular networks
AI	Artificial Intelligence
CGS	Council for Geoscience
CSIR	Council for Scientific and Industrial Research
GHz	Gigahertz
HEI	Higher Education Institution
ICASA	Independent Communications Authority of South Africa
IoT	Internet of Things
ITU	International Telecommunication Union
kHz	Kilohertz
LoRaWAN	Long Range Wide Area Network
LPWA	Low-power wide-area
LTE	Long-Term Evolution
MB	Megabyte
MHz	Megahertz
Mintek	Council for Mineral Technology
NB-IoT	Narrowband Internet of Things
NMISA	National Metrology Institute of South Africa
NSTF	National Science and Technology Forum
pro*SET*	Professionals in Science, Engineering and Technology
SMME	Small, Medium and Micro Enterprise
SUN	Stellenbosch University
UJ	University of Johannesburg
UP	University of Pretoria
LDARD	Limpopo Department of Agriculture and Rural Development