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Unpacking new technologies

Internet of Things Technologies and 5G

#IoT #5G @NSTF_SA @pro*SET*

Information and Communication Technology (ICT) is such a critical component of our lives and work that it's no longer something we can leave to the tech experts. "We need to be informed about new technologies and developments so that we are part of the debate," says Jansie Niehaus, Executive Director of the National Science and Technology Forum (NSTF).

As part of informing the science, engineering, technology (SET) and innovation community, an NSTF Discussion Forum was held on 23 November 2020 via Zoom. The online seminar, with interaction and discussion, looked at 'Internet of Things (IoT) technologies and 5G roll-out'. It was hosted by the NSTF's Professional Bodies and Learned Societies sector called pro*SET*.

What is IoT?
IoT refers to "a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention".

The NSTF provides neutral collaborative platforms where issues and sectors meet

- One of the National Science and Technology Forum (NSTF) functions is to hold discussion forums, bringing the private and public sector together to address important issues and engage with government policy.
- Feedback from these discussion forums is given to role players and stakeholders.
- Recommendations are put forward to government as part of the SET community's (science, engineering and technology) efforts to make input into SET-related policies and implementation.

There are many IoT scenarios that show clear benefits. Imagine parking spots (with sensors) that pass on data about availability to an application in the cloud (internet). Drivers can access the information to quickly find a parking space.

Consider sensors in a greenhouse measuring temperature, humidity, pests, water etc. The embedded devices could monitor and manage conditions. For example, the temperature lowers and the system receives this information from the sensor, and then increases the temperature to the appropriate degrees centigrade without human interaction.

In an inventory environment, items with attached sensors would allow a system to track exactly where something is and if items are running out (and need to be topped up). The sensors would alert the system if an item is taken without permission.

Data is gathered and analysed, providing real-time information to make decisions or to set off an automated response (as part of the networked system). So, an internet-connected borehole pump can be monitored to check that pump parts are working and to measure water level, for example. The sensors are set up so they only become active when there is a problem and then send through data to the network, which then creates alerts about the problem. A technician can then be sent out.

The types of sensors depend on need and environment. They include sensors that measure temperature, motion, moisture, air quality, and light. The data gathered from IoT environments can reduce operating costs, improve efficiencies, streamline operations, provide usage patterns and so on. 'What is IoT? Defining the Internet of Things (IoT)', report from Aeris, IoT company in India.

IoT and radio waves
IoT networks use radio waves – these are also used for cellular telephony, radar, navigation, wireless networks, and to broadcast tv and radio. Radio spectrum can be divided into licensed and unlicensed bands. Licensed bands can only be used by the company that licenced and paid for it. Unlicensed bands are not exclusive but are regulated.

Low power in IoT networks
Items need to have readily available power sources – usually batteries – to be part of the IoT network ie to send and receive information. The aim of most IoT environments is to create a low power scenario so that the power source doesn't need constant replacement. This was part of the explanation from Sean Laval, Executive: Solutions and Innovations, Sqwidnet, a national IoT network provider. He presented on 'IoT network technologies'. "You need multiple years of service before changing a battery to justify ROI [Return on Investment]," he says.

Data amount linked to power and cost
"IoT devices need to send a few bytes of data when an event happens which means they don't use a lot of data. Only a small percentage of IoT devices require high data per month," says Laval. Examples of the latter include cameras and data-intensive tracking applications for fleet management. He notes that "more than three quarters of IoT devices need less than 1Mb of data per day". With high data rates come high energy use and cost.

Looking at wireless IoT network connectivity
Laval looked at IoT networks according to energy use (the energy use reflects the data rate):

- **At the top is *3G*, *4G* and *5G***. These need a lot of power due to high data requirements. This is for high quality of service (QoS) such as for self-driving cars and cameras. These networks have national coverage.
- ***LTE-M*** is for slightly lower power consumption. It also offers national coverage for fairly high-powered devices and is good for fleet tracking and cameras.
- **In the middle is *NB-IoT*** which gives city coverage for battery-powered devices. A use case example is energy metering. *NB-IoT* is fairly expensive to deploy as it's licenced spectrum. (*NB-IoT* falls under the 5G standard.)
- ***LoRaWAN*** is a proprietary technology. It's for community or private networks for small messages. An example is a private network in a rural agricultural setting. These networks are not national in South Africa. It's a good option for a network that supports years of battery life where you still want full control of the network.
- ***Sigfox*** is also a proprietary technology, designed for a really low-end IoT network which could involve billions of devices. It can create a global network of small

messages. This is for the type of IoT environment which relates to monitoring and relaying really simple data: Did a door open? Did somebody walk into a room? Did the temperature go over a certain level? Did the asset move into a certain geofence (a virtual boundary of real-world area)?

5G technology standards

Dr Fisseha Mekuria is Chief Researcher at the Council for Scientific and Industrial Research (CSIR): Networked Systems and applications, Next Generation Enterprises and Institutions, and Head: CSIR Smart Spectrum team. He presented on '5G+ Tech Standards & IoT: The path to autonomic networks and the networked society'. This started with explanations on the different wireless network generations.

The different generations

The first-generation wireless network (*1G*) was developed in the 1980s. It supplied basic voice services using analog devices. From mid 80s through to the 90s, came the next generations of wireless networks – *2G* and *3G*. There was improved coverage and capacity. With *2G*, the world saw the first digital standards.

Mekuria explains that standards are verified by the ITU, a body that oversees networks globally. The standards ensure infrastructure compatibility with all the technologies involved 'talking' to the same network core. (The International Telecommunication Union – ITU – is a specialised agency of the United Nations that is responsible for ICT matters.)

The *3G* wireless networks brought voice and other data activities: multimedia communications, texts and the internet. This standard needed to account for the great increase in people becoming connected, as well as new data activities. The *3G* wireless networks also brought about the flexibility of working from anywhere.

With each new generation of wireless network, speed has increased dramatically. Consider that *3G* was 2000 kbps to *4G* at 100,000 kbps. The *4G* networks are designed primarily for sending data using internet protocols (IP). The term '*LTE*' is the standard associated with 4G. (The full name is 'Long Term Evolution'.) This wireless network gave us true mobile broadband and marked the time of the smart phone, says Mekuria.

The fifth-generation wireless network (*5G*) is already here, with even faster speeds (1-2 Gbps). Mekuria says that it's ready to support smart cities, industrial automation, IoT, and more. But don't get too comfortable because *6G* is being developed. This generation includes new ways of optimising networks (for more bandwidth, coverage, and to connect everywhere) and green networks (for reducing energy use and using green sources of energy).

5G standards for different use cases

Mekuria notes that *5G* is a group of technology standards that support different use cases (or scenarios). Examples of standards that fall under this are: Enhanced mobile broadband (allowing *4G* radio systems to be used with a *5G* core network) and Massive Machine Type Communications (MTC) using low power so that smart sensor networks can communicate. Work is also being done on technologies and standards for affordable broadband to cater to rural and underserved areas. (*NB-IoT* is one of the *5G* technologies).

The *5G* use case scenarios need to support industry but there also needs to be social value, says Mekuria. This includes medical care, transportation, the energy sector, and intelligent transport sectors.

"It requires that we work together ie we need public-private partnerships. This includes regulators, industry, the CSIR and government. We can then develop the social value working together for safer cities and public services, to improve the quality of people's lives, and to build

industry's ecosystem and thus develop SA's economy," says Mekuria.

He further notes that ethics are key in the move to a networked digital society. An example is digital inclusion rather than only rich areas acquiring more bandwidth with rural areas being left behind.

Developing innovative applications for *5G*
Mekuria says it's important to have a *5G* testbed for developing innovative applications and that testbeds accelerate use case scenarios. Launched in Kenya in 2007, *M-Pesa* is a world-renowned mobile phone-based money transfer service and payments and micro-financing service. It's an example of an application that started through experimentation in a testbed. (The mobile operator had provided a testbed for developers to experiment with *3G* technologies.)

The CSIR, with international collaborators, is building a *5G* technology testbed. Although still under development, Mekuria says it's being used to test some use cases, such as self-driving vehicles. The aim is to encourage innovators (such as university students) to come and develop *5G* use cases, apps and services.

About *LPWA* networks
NB-IoT, Sigfox and *LoRaWAN* make up the majority of **low power wide area (LPWA) networks** today. Laval says that technologies that fall under LPWA address the same requirements: low cost, low power, long range, reliability, and security.

LPWA networks haven't been available until recently. Essentially, you get national coverage similar to cellular network but at a low power consumption. It opens up a lot of applications that weren't feasible before, such as water metering over a large geographical area.

Laval says that LPWA networks have come about because costs have come down, from core components to improved battery technology. Furthermore, there is now access to cloud infrastructure where different services are delivered over the internet.

Comparing *NB-IoT* with *Sigfox* and *LoRaWAN*
Laval says that *NB-IoT* came about as a response to proprietary networks with lower power consumption. *NB-IoT* is deployed within the 200kHz frequency. Laval says that, in a spectrum-starved environment, using this spectrum for something that doesn't yet generate as much revenue as core data traffic from traditional users can be a tough business case to justify. However, it's still seen as part of the future of IoT.

NB-IoT networks allow high data rates. This can be used for fleet management and electricity meters that need second-by-second load profiles. This type of data is, generally, not a low power requirement. There are a number of other advantages including the ability to control a device (ie switch it on and off) and guaranteed quality of service. However, these all eat into battery power.

Drawbacks include higher power consumption, higher module costs and coverage (but this will improve over time).

Sigfox network and LoRaWAN
In SA and Europe, the *Sigfox* network uses the 868.1 MHz centre frequency. This is an industrial scientific and medical (ISM) band. It uses a narrow band of this (192KHz wide), and the network is built around an **ultranarrow band (UNB) modulation scheme**.

High quality of service and massive capacity come from the ultranarrow band (UNB) modulation scheme. This scheme fits many messages at once into the channel, as well as:

- Time diversity where a message is sent three times by hopping from one frequency to another (within the allocated UNB frequency). This gets around time-based interference.
- Frequency diversity comes from this hopping, meaning it gets around interference based on using the same frequency.
- Spatial diversity is due to messages from a device received by at least three base stations simultaneously. Even with interference across a wide time span and wide frequency spectrum, chances of interference across multiple base stations and across multiple square miles is low.

The above also means the network is resilient to jamming. Laval says this is key for the security sector and the stolen vehicle recovery sector. Advantages of proprietary low power wide area (LPWA) networks (like *Sigfox* and *LoRaWAN*) include reduced costs due to low power consumption and low device costs.

Disadvantages include limited messages per day due to low bandwidth. These are also asynchronous networks ie devices don't initiate communication and can't be controlled in real time. These type of IoT networks support devices such as: personal tracking devices, security devices and water meter devices.

Spectrum sharing
The CSIR would like to see spectrum sharing and Mekuria is the leader of the team that developed the Smart Spectrum Toolbox. It was a 2020 NSTF-South32 winner for Innovation by a Corporate Organisation. It's an innovative spectrum sharing and management system with a suite of technology products known as the CSIR Geo-Location Spectrum Database (GLSD). It provides a cloud interface service, designed to provide spectrum availability information to new entrant network operators.

It detects unused radio frequency spectrum areas in the Ultra High Frequency (UHF) bands. These identified spectrum white spaces are made available for broadband internet services, thus improving affordable digital connectivity. This process helps to accelerate the deployment of wireless ICT services, as well as providing impetus for the creation of SMMEs that deploy network infrastructure and provide affordable broadband internet.

The business model involves digital SMMEs, based in rural areas. These businesses would provide broadband internet services to rural and underserved communities using the CSIR Smart Spectrum Toolbox. Mekuria sees it as part of the solution to bridging the urban and rural divide with affordable and sustainable rural connectivity.

Wireless network coverage in rural areas?
As noted above, the CSIR are currently working on capacitating digital SMMEs (small, medium and micro enterprises) to provide broadband. TV spectrum is being used as a cheaper option but Mekuria says that *5G* can be brought in later as the economy grows.

While *Sigfox* has 93% coverage of the SA population, it means the coverage occurs where people live ie mainly urban areas. However, *Sigfox* can facilitate coverage in rural areas, says Laval. An initiative with the University of Johannesburg (UJ) involved Gwakwani village, Limpopo, where an IoT network has been deployed using solar power. This allows the UJ academics to monitor – from a distance – the borehole, safety and security at the creche, and equipment performance at the bakery.

Laval says that now UJ can pick up anomalies early enough. An example is when a pipe was blocked in the borehole, which would have caused the pump to seize. However, they caught it in time through visibility with IoT.

Prof Jan Meyer, the academic lead of this project, has called it 'Village 4.0'. The aim is to duplicate the concept in other villages around South Africa and Africa, says Laval. It can significantly enhance lives with a relatively low investment. Find out more about the project. Laval says that *Sigfox* does cover some rural areas but this is based on demand and looked at on a case-by-case basis. As *Sigfox* is a commercial enterprise, the business case needs to work. He says that demand in rural areas is primarily driven by farming ie efficiency in agriculture and tracking livestock.

The Smart City
Mekuria believes that one of the most important *5G* use cases is where we efficiently use natural and technological resources for the benefits of society to create a Smart City. Through IoT networks (as well as other networks), smart sensors can be embedded everywhere to collect data to create and optimise Smart Cities.

By optimising the use of resources (through data feedback and analysis), we can reduce costs. Furthermore, predicting demand allows for effective planning, and customising offerings enhances efficient delivery. Examples include smart power grids, traffic management, smart parking, utilities management etc.

Mekuria does offer a warning regarding technology – we need to consider its relevance and ethical use. Technology can also be used for harm, such as illegal surveillance and other privacy issues.

Mekuria says that *5G* is now being commercially rolled out in SA and globally. While it's a global standard, technical regulations, business models, policy, and ethics of use are still in their infancy. He sees *5G* and IoT and the associated technologies and skill sets as part of realising the Fourth Industrial Revolution (4IR) vision. You can find out more about 5G technology and use cases for Africa in the CSIR and Ericsson White paper, 'Making 5G a reality for Africa'.

Safety issues
Noting the health claims that had been made around *5G*, Mekuria says that this is a highly regulated space internationally and that *5G* does not have detrimental health effects. The CSIR has a report, 'An assessment of claims regarding health effects of 5G mobile telephony networks', from May 2020 with further details.

Speakers can be contacted through the spokesperson, Ms Jansie Niehaus. Further information can be found on the NSTF website and the NSTF YouTube channel.

There are many presentations from experts on the NSTF YouTube channel. Have a look at:

- Technology transfer in manufacturing and minerals processing – 4IR technologies SA needs to acquire – click here
- Career paths for researchers – where to in a changing world? – click here
- Plastics – substitutes vs recycling – click here

About the NSTF

The National Science and Technology Forum (NSTF), established in 1995, is a broadly-representative stakeholder body for all science, engineering and technology (SET) and innovation organisations in South Africa, which seeks to influence policy formulation and delivery.

The NSTF Awards are unique in SA, recognising the outstanding contributions of individuals and groups to SET and innovation.

The science bursaries page provides information on bursaries and bursary providers for science, engineering and related studies.

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Non Profit Company Registration Number: 2007/029165/08
NPO Registration Number: 92042