THE FUTURE OF THE WESTERN CAPE AGRICULTURAL SECTOR IN THE CONTEXT OF THE 4TH INDUSTRIAL REVOLUTION

Review: Internet of Things (IoT)

October 2017

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1. What is the Internet of Things?

Introduction

The Internet of Things (IoT) refers to any object that is connected to the internet. In the past, we would only have thought of computers and more recently smartphones as being connected to the internet. However, in today's economy there are a multitude of connected sensors and devices, from thermostats in homes, to wristwatches, cars, lights and many other items. Internet connected things can communicate and react with each other, without the need of human intervention. This is creating a truly vast array of networks and sensors.
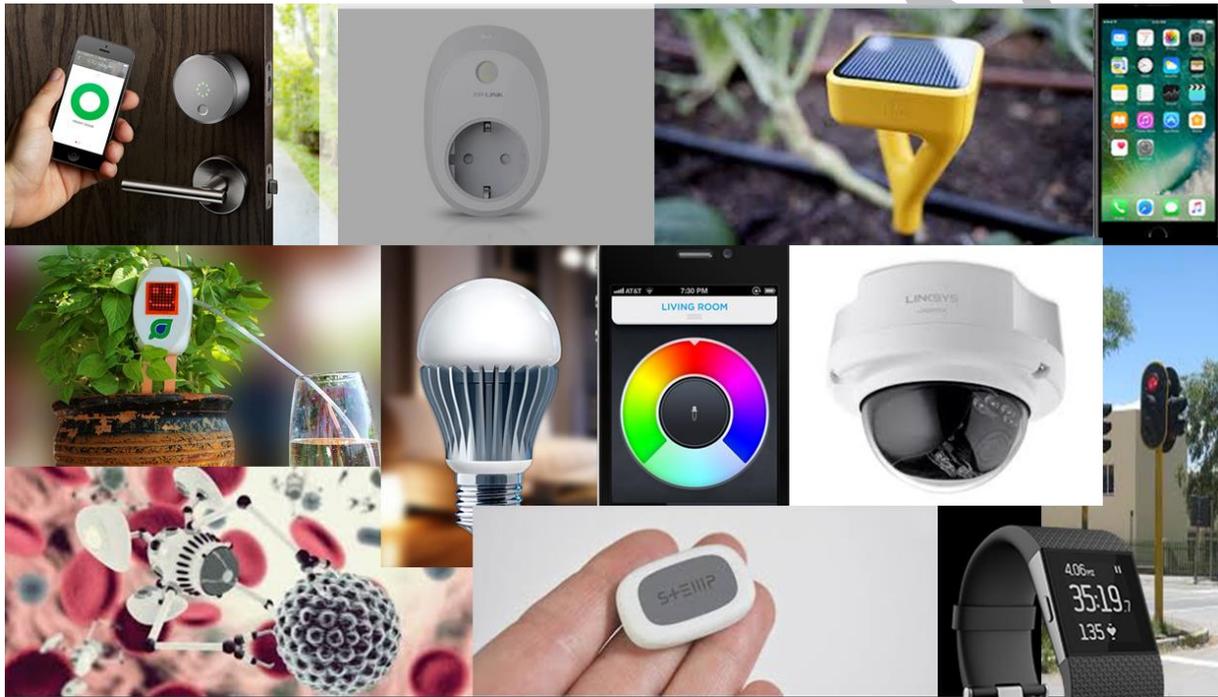

Figure 1: A selection of IoT devices

Why does IoT exist?

IoT allows us to collect data on a massive scale. When we connect an everyday object to the network, we allow that object to send information about its state to a central database. For example, heart rate monitors allow for internet connected human hearts. When we allow the human heart to send information to a central database, we can then compare that data to other metrics (exercise, diet, illness) which allow the medical industry to understand how the heart behaves in relation to other metrics about our bodies. By analysing these relationships, we can establish the best conditions for proper heart functionality and advise humanity on how to mimic those conditions for better health.
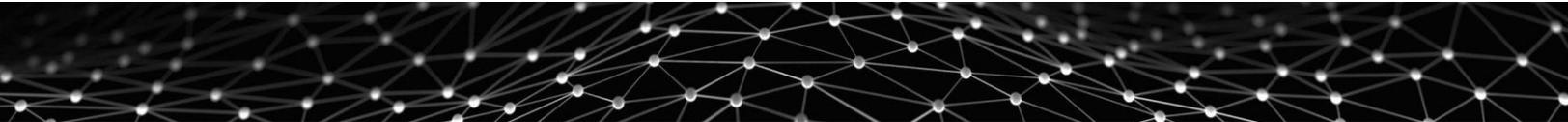
Connected devices allow us to achieve efficiency on a number of different levels. We can save electricity by analysing the conditions of our connected-geysers, we can save time by having our connected-fridges order us groceries when we need them, we can save water by having our connected plants tell us when they have had enough irrigation. We can continue to improve on all of those savings by collecting all of the data captured by all of the connected things, and understanding new relationships by using machine learning techniques to analyse the data and prescribe optimal conditions for each connected thing to exist in.

2. Why is IoT important now?

Reducing Device Costs

IoT has been made practical through a drastic reduction in the cost of technology. This reduction in cost stems from the exponential improvement in price vs performance which we now recognise as being driven by Moore's Law. Projections vary, but the number of internet connected devices is set to reach between 30 and 50 billion by 2020, at a compound annual growth rate of roughly 35%. This is a staggering rate of growth and would not be possible without devices becoming cheaper due to reduced pricing in computer chips and batteries, and economies of scale through mass adoption and production. For example, the price of a Samsung Internet Protocol (IP) camera was around $1,500 in 2010 whilst a Samsung IP camera costs $480 today and is far superior in terms of resolution and performance.

This drastic improvement between price and performance has been mirrored across thousands of different devices and sensors. This has made these technologies very affordable. The effect of this is easily recognised with IP cameras, where these devices can be seen in shopping centres, petrol stations, homes, and smaller independent retailers to name a few. The latter two examples being a prime indicator of the affordability of the technology in particular.

Better ICT Infrastructure

Fibre optic networks and 4G mobile connectivity have also paved the way for the IoT revolution. This infrastructure is key when it comes to connected devices sending data to the cloud for analytics in real time. The smartphone is at the heart of much of the collection of data from sensors which in turn gets sent to the cloud. Smartphones are far more powerful and user friendly since the advent of 4G and WiFi. Smart cameras used in a number of different applications would also not be feasible without the extensive network of fibre optic cables found in most major cities. Cloud computing services have also enabled IoT by allowing data storage and machine learning to be conducted at remote data centres. This allows

devices to be smaller and not contingent on being connected to local hubs which can decrease network flexibility.

Big Data and Machine Learning

Collecting data from everyday objects is pointless unless we can analyse that information in order to improve our lives. IoT devices generate many petabytes of data which would be impossible to meaningfully analyse (particularly in real time) by data scientists. The rise of machine learning capabilities is allowing us to analyse huge data sets in order to find opportunities for optimisation in everyday life. NEST, a company supplying smart thermostats (acquired by Google for $3bn) provides an excellent example of this. By analysing data collected by all NEST thermostats across the U.S., the device was able to figure out that electricity was heavily used in a reactionary fashion. When the weather turned cold, people cranked up their heating and used a great deal of power in doing so. By analysing weather data to predict incoming cold weather, NEST was able to save large amounts of power by gradually heating houses before the cold weather arrived. Houses remained ambient despite the fluctuating temperature outside.

In order for a technology to achieve widescale adoption, the benefit of doing so needs to be very tangible. Machine learning has allowed us realise valuable benefits from having our devices connected to the internet, which incentivises us to continue the growth of IoT in other areas of our lives.

3. What are the applications of IoT today?

Smart Cities

Smart cities have received a great deal of attention in the press and are often touted as a use case for IoT in the future. The reality is that cities like Barcelona and Chicago have already experienced the positive effects of connected cities. Over the past 7 years, the city of Barcelona has initiated a program called Smart City Barcelona. The program identified 12 areas for intervention for IoT, including transportation, water, energy, waste, and open government, and initiated 22 programs, encompassing 83 distinct projects across urban systems.[1]

The city installed 19,500 smart meters that monitor and optimize energy consumption in targeted areas of the city. For waste management, households deposit waste in municipal smart bins that monitor waste levels and optimize collection routes. To curtail traffic, Barcelona has installed sensors in the road surface which detect whether a car is parked in a parking space or not. Drivers use a parking app called ApparkB which guides them to open

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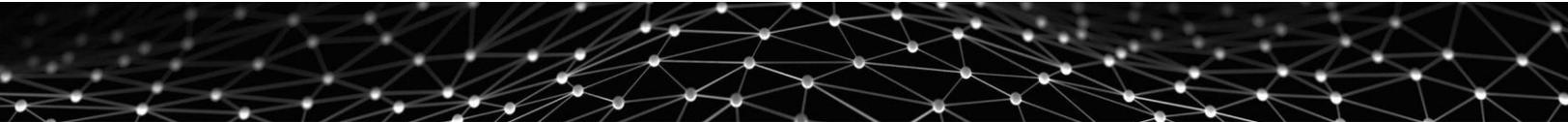
parking, reducing congestion and emissions. The app also allows drivers to pay for parking online. Within a year of implementation, the city was issuing 4,000 parking permits per day through the application.

The Barcelona Lighting Masterplan uses smart technologies to enhance the efficiency and utility of city lampposts. By 2014, more than 1,100 lampposts had been modified to LEDs, reducing energy consumption. These smart lamps sense when the street is empty and remain dimmed until required by commuters. They also act as wifi hotspots, expanding the network of internet connectivity in the city. The lampposts also have air pollution sensors, feeding back valuable data to the city. Cumulatively, these improvements produced 30% energy savings across the city's lighting system.

Barcelona also installed sensors to monitor rain and humidity in parks. This informed a system of electrovalves that remotely controlled water supply across the city. The program was implemented in 68% of public parks and helped the city achieve a 25% increase in water conservation, saving the city about $58million per year.

Chicago has also seen significant benefits by implementing sensors. For pest control, the city hase used sensors in dumpsters and predictive analytics to determine where to place bait for rats. By listing which dumpsters are most likely to be overflowing, the city is now 20% more efficient in controlling rats, said Tom Schenk, chief data officer for the city of Chicago.

Predictive analytics are also being used to dispatch food inspectors to the city's 15,000 restaurants by using variables to predict which businesses are most likely to have code violations. In an 8-week trial of the program, restaurants with code violations were found two weeks faster, on average, than they would have been without predictive analytics, Schenk said.[2]

Smart Factories

Connected sensors are being effectively deployed to make smart factories. U.S. based, Ergon Refining has implemented IoT devices into one their Vicksberg facility to monitor production. Sensors were installed for steam trap monitoring via wireless acoustic transmitters to monitor when traps fail. Failures allow high-pressure steam leaks, resulting in more steam being produced by boilers. Depending on the price of steam at a facility, a single failed-open steam trap can waste $30,000 worth of steam each year.

When traps fail to close, they don't remove water droplets from the steam. These water droplets, moving through piping and equipment at a high rate of speed, can rupture steam lines and cause turbines to throw blades. Repairs are very expensive, and downtime is often

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significant. Most plants monitor their steam traps manually via annual checks. This is very costly in terms of labor, misses many problems, and in the worst case can allow failed traps to operate for years.

Acoustic sensors and specialized software systems detect steam trap problems automatically and alert plant personnel so they can take action. In the past, these sensors were wired back to software systems, but the preferred modern method is to use wireless acoustic sensors connected back to software systems via a wireless mesh network. These wireless sensors are battery-powered and can operate for up to 10 years between battery changes. Compared to wired sensors, installation takes place much more quickly at significantly lower costs, and required plant downtime for installation is greatly reduced or eliminated.

One corn milling plant was experiencing a 15% annual steam trap failure rate, with 12.5% of the plant's steam traps responsible for 38% of the steam loss. The plant addressed this issue using wireless steam trap acoustic sensors and accompanying analytics. The payback period was just a few months, and the annual savings were $301,108.

Another IoT example is monitoring valves controlling gas flows to flare stacks in refineries. Using wireless acoustic transmitters, one refinery improved regulatory compliance and reduced hydrocarbon losses by $3 million annually due to timely detection and repair of faulty valves. The project paid for itself in five months, with an estimated annualised return on investment (ROI) of 271% annualised over 20 years.[3]

Agriculture

The Oxnard region in California, known for strawberry production, is not only battling water shortages due to the ongoing California drought, but also salinity issues stemming from depleted water sources, saltwater intrusion, urban and agricultural use, and treated water discharged into waterways. In order to maximise efficiencies from an increasingly scarce resource, El Rio Farms implemented a network of sensors in order to monitor soil conditions and implement precision agriculture.

Pal Halstead, Operations Manager at El Rio said their strawberry operation was able to cut water use by about 27%, thanks to precision irrigation practices such as drip irrigation and "smart" soil tension monitoring sensors. The system allows a high level of optimisation in water usage. The system is also able to reduce damage due to frost by automatically activating wind machines should the temperature recorded through sensors, drop below a certain level.

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Figure 2: An internet connected soil sensor. Source: Edyn

In South Africa Jozeph du Plessis a grain producer from Schweizer-Reneke in North West, cultivates dryland crops on 3 600ha. He has practised precision farming since 2001. Du Plessis rotates his main crop maize, with soya beans and sunflowers. He started his precision programme with yield monitors and satellite imagery. In 2002 he surveyed his lands on a 1ha grid overlay, mapping the physical properties and chemical status of the soil. Spatial features were digitised with Agleader's spatial management system. Computerised models calculated the potential maize yield using calculated soil water holding capacity. Jozeph replaced low potential areas with pasture. Nutrient levels in each hectare were analysed and built up systematically to optimal levels, which meant that the soil could be used at its true potential.

Du Plessis uses a neutron moisture meter to monitor soil moisture in identified positions before planting. To manage low water content detected on some lands he implements a fallow system. A third of the cultivated area is left fallow for a season to conserve water. The farm also plans to introduce variable planting rates. These innovations have increased average maize yield from 2,98t/ha in 2000 to 7,01t/ha in 2012. Water use efficiency increased from 185mm rain per ton of maize produced to 91mm rain per ton of maize produced, calculated from a mean five-year rainfall.[4]

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4. What is the Future of IoT?

Infrastructure

In our report on ICT, we document the upcoming rollout of Low Power Wide Area (LPWA) networks specifically to cater for IoT devices. Such is the importance placed on IoT that Mobile Network Operators are installing low power wireless networks to capture the increasing demand for IoT connectivity. IoT in agriculture is limited by current connectivity in outlying regions. LPWA will go a long way to solving these issues, providing infrastructure that has been specifically designed for IoT to service sensors distributed across farms.

Weather prediction

90% of all crop losses are due to weather. With an IoT platform that can integrate IoT and weather data, farmers would be able to build predictive weather modeling driven by machine learning. This can provide the insights that help farmers to make strategic decisions on planting crops and take necessary actions to prevent the damage caused by extreme weather. With weather data, farmers can then adjust irrigation systems to save water and prevent pesticide waste by predicting rain.[5]

Supply Chain

IBM Research's Precision Agriculture is aiming to help farmers use data to make precise decisions from planting, growing, harvesting, to transporting food. The ability to monitor and track the route of food delivery can not only save food waste but enable food safety. Up to 40% of food is wasted in the U.S., which is estimated to cost approximately $165 billion each year. 50% of the food waste happens during distribution. To define the best route to transport food with the information of weather and all environmental conditions is a critical step to prevent food waste. Moreover, food companies now monitor the production and delivery process to control the quality of food. People can know where their food came from due to the transparent food supply chain.

Disintermediation

By connecting farmers with real-time pricing data, intermediary agents are likely to come under strain as farmers cut out the middleman to unlock better margins by selling directly to retailers. Technology companies such as Aggregator, are building platforms where groups of small farmers can achieve negotiating power through collective volume. By connecting retail outlets with farms and digitizing produce exchanges, this connected network will remove a great deal of friction in the market. This will benefit farmers as they receive better pricing,

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however, intermediary agents will be severely disrupted as technological innovation increases market efficiency.

5.   IoT Application Life Cycle

IoT is a classic case of a deceptive technology. Many may feel that IoT is in its innovation or early adoption phase, but IoT is already all around us. From Fit Bits to car trackers to the myriad sensors in a smartphone, IoT is closer to an early majority phase with rapid adoption driving it forward. From an agricultural viewpoint in the Western Cape, IoT is in an early adopter phase. But improvements to infrastructure and the high ROI on sensors will mean that IoT will impact the region heavily in the next 7 – 10 years and become common-place for many years thereafter.

6.   Business Eco-System View

As mentioned above and in our report on ICT, IoT is being heavily adopted from a business ecosystem point of view. All the big network providers are rolling out solutions for LPWA networks. If these networks are slow to arrive in farming communities then farmers can buy affordable LPWA antennae themselves as the technology continues to drop in price. From a sensors perspective, there are thousands of providers, predominantly in Asia making sensors that are cheaper each year. Companies like Hyundai are so bullish on IoT that they have launched an entire cryptocurrency (HDAC) to cater for the machine economy. The ecosystem continues to grow and will create a flourishing industry over the next decade and beyond.

7.   Benefits and Risks

The benefits of IoT have been outlined in the sections above but can be summarised as a drastic increase in efficiency given limited input resources for agriculture. Cyber-security is a big risk with IoT. Once all devices are connected to the internet, they become available for hacking. Terrorist groups or competitors may be incentivized to manipulate device or market data. It is vital to have proper cyber-security in place for any connected network. In South Africa, a risk of theft will always be an issue for sensors or drones carrying sensors. There is a slight economic risk that the installation of an IoT system would not benefit the farmer if the farming was performing at close-to-perfect levels of efficiency from an ROI perspective. We believe if the technology is implemented correctly that this risk is very unlikely.

8. Potential Economic, Social, Ecological and Political Developments and Impacts

Sensors have the capacity to take readings automatically which would negate the need for a human being to do so. We do not believe this will have a large impact on jobs. If anything, the addition of sensors will lead to higher employment as an entirely new industry emerges requiring installation, maintenance and add on services. Thus, from a political, economic and social standpoint IoT will have a net positive effect. Ecological impact may need further investigation. Precision farming through IoT leads to better yields and better use of resources. However, this may increase things like water usage because plants are using more water to make more produce per plant. In an area where water is scarce, this would cause an issue. Perhaps it is optimal to grow less food and preserve water if a solution to the water crisis cannot be solved?

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