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The Internet of Things, Progress Report for Africa: A Survey

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ABSTRACT

The last seven years have seen ”buzzing” activi-ties across the globe among technology practitioners, private businesses and education institutions geared towards Internet of Things (IoT). According to Cisco, in 2013 about 80 things were being connected to the internet per second, by 2020 it is estimated that about 250 things will be connected to the internet per second, thats´ about 50 billion things [54]. According to Gartner Machine to Machine (M2M) communication will generate incremental revenue exceeding $300 billion, mostly in services, by 2020. It will result in $1.9 trillion in global economic value-add through sales into diverse end markets [48]. World over businesses are positioning themselves to tap into the huge potential that exists in ubiquitous networks in various sectors. While many developed countries have a beehive of activities and projects in relation to Wireless Sensor Networks (WSN), Africa have had very little activities. This research is meant to survey the progress that various African countries are undertaking. We intend to survey various IoT activities in selected African countries document their progress and conclude on the level of intake of IoT in Africa. We will also document some of the challenges affecting adoption of IoT in the continent.

Keywords: *Internet of Things, Wireless Sensor Networks, Machine-to-Machine Communication, Ubiquitous Networks.*

1. INTRODUCTION

Today, many devices are getting connected to the internet than have ever been imagined, from Cisco widget, a project that has been founded to estimate how many devices are getting connected daily in real-time it is estimated that nearly 100 devices will be connected to the internet per second by the year 2015 while approximately 250 devices will get connected per second in the year 2020, that translates roughly to about 50 billion connected devices in 2020 [55]. The connection of devices or machines is projected to results in generation of massive data, enabling interaction of things with each other and with humans. This will revolutionize basic processes in day-to-day activities. The emergence of Ubiquitous sensing enabled by WSN technologies has infiltrated many areas of modern day living. This now makes it possible for real-time measurement, inference and understanding of environmental indicators, from delicate ecologies and natural resources to urban environments, control of traffic and parking in urban centers, waste water management, possibilities of e-health, precision Agriculture , air traffic control, electricity among others. The proliferation of these devices in a communicating-actuating network creates the IoT, wherein, sensors and actu-ators blend seamlessly with the objects around us, and share information across various nodes and applications in order to develop a Shared Operating Environment (SOE) [56]. The IoT can be defined as the connection of day to day common objects when they use embedded sensors, actuators, and other applica-tions and devices that can collect and/ or transmit information about the objects, the objects can communicate with each other or with humans. The data amassed from these devices can then be analyzed to optimize products, services, and operations [57]. Recent research by Gartner in the year 2014 shows that the increasing growth in the number of Internet-connected things will have great impact and gigantic force that will transform the way businesses operate including their goals and strategies, this will in turn results to a disruptive impact across all industries and all aspect of society. It is estimated that about 4.9 billion things will be connected and in use by the year 2015, which loosely translates to 30 percent growth from the year 2014 when this research was done. The continued growth is expected to reach 25 billion connected devices by the year 2020 [48]. Gartner reports that product and services supplied by IoT companies will realize upward revenue growth surpassing $300 billion, mostly by providing services, by the year 2020. It will result in $1.9 trillion in global economic value that will come from diverse markets [48]. In Europe, USA, China and many other Technology developed countries the enterprises, institutions of higher learning, research centers and individual professionals have taken up the idea of IoT with Gusto. There is a dramatic race to pick up and adopt IoT with the enthusiasm that was not seen in the past decade. For many players it is an idea whose time has

come [58]. These countries are integrating IoT in their day to day activities, for example 15th of July, 2015 French president Mr Francois Hollande opened Europes´ biggest centre dedicated to IoT technology.
The 10,000 sq m Cit de lObjet Connect is expected to innovate new technologies among others heating thermostats that talk to a mobile phone, litter bins that connect remotely to refuse trucks and hives that communicate with beekeepers [1]. In the United States big corporations like Microsoft, IBM and General Electric among others have taken the leading role in integrating IoT with their products and solutions [59]. In China Huawei, one of the largest Chinese technology company have developed an agile platform of IoT that can be installed in cars and homes to enable common communication of these objects amongst themselves. The platform which runs on its own operating system called eliteOS is expected to be a free standard that can be used by other devices in order to connect and communicate with each other [2]. The South Korean government has committed twenty trillion Won to develop IoT in the car business, starting this year. According to the South Korea Ministry of Science, ICT, and Future Planning and the Ministry of Trade, Industry, and Energy, the governments´ goal is to foster an IoT and smart car business by 2024 that will be worth 100 billion won ($90 million) [3]. Research by pew global, done in 2014 shows a picture of tremendous rush by many developed nations to take up IoT activities [4]. Contrary to the growing a petite in developed countries to take up IoT, Africa seems to lagging behind and few activities really seem to be going on in the continent. While we believe IoT can without doubt revolutionize business in Africa and help tackle many challenges faced by the continent, it seems that Africa have not taken seriously how IoT can contribute to alleviate poverty, malnutrition, health, and generally improve quality of life. In this survey we will delve in the depths of IoT uptake in the continent, documenting various activities that are happening and how they have revolutionize their processes, we will study how Usangu Logistics Limited have imple-mented and adopted RFID to manage their oil distributions channels in Tanzania, look at sensor based product verification initiative in Nigeria adopted by National Agency for Food and Drug Administration and Control (NAFDAC) and Health Applications developed in Ethiopia to monitor antiretroviral and AIDS therapies. In Kenya we will look at how Nairobi County council is using IBM developed sensor devises to manage the garbage collection in order to improve efficiency and reliability, we will then study a system to monitor water quality in Malawi which is under development at the Royal Institute of Technology in Sweden, the survey will also look at the Guateng highway e-tag tolling system and Eskoms´ South Africas´ public electricity utility Company ”Utility Load Manager” a residential load management system that allows the utility to limit residential loads and to integrate end-user, in South Africa. In other countries like Egypt, Tunisia and Rwanda governments are committing funds that are geared towards development of ICTs including IoT to improve lives of their citizens. In section two we will delve briefly on related work before we discuss current IoT activities in Africa in section three, section four will cover challenges facing slow adoption of IoT in Africa, then we will conclude in section five.

2. RELATED WORK

IoT adoption in Africa being a new area of interest has not generated many publications to write about, however the few publications have concentrated in suggestions of various applications that can be used to develop IoT in the various countries and how they can revolutionize peoples´ lives. Dr. Muthoni Masinde of Central University of Technology (CUT) in South Africa says that the pace of technology advancement in Africa is very slow; the continent seems very comfortable contending for bottom position in every sphere of technology. She says that an example is in the Information and Commu-nications Technology where Africa currently has 7 percent of her people connecting to the Internet; this number is far distant lower compared to the worlds´ figure of 41 percent. However, Dr. Muthoni believes that all is not lost; that some evidence is available showing the continent could lead in certain areas of technology advancement. She concludes by posing a question, as researchers and business enterprises around the world compete for vantage positions in the uptake of IoT, and in consideration of Africas´ eminent lack of technology required for implementation of IoT, what should be content choose between innovation and adoption [6][5]. Finbar Toesland commenting on Africas´ business magazine said that South Africa being one of the most economically developed country in Africa has developed much better infrastructure and could leap ahead of others in taking up IoT projects. Already ESKOM (South Africa) the utility company adopted smart meters to measure electricity usage within the households under their service; elsewhere Rwanda has integrated simcards to Point of Sale (POS) terminals in some remote areas to allow for acceptance of credit payments [7]. Recent estimates by research firm Mckinsey shows that by 2025 there will be over 50% internet penetration in Africa, thats´ about 600 million people, tripling the current connection levels. And owing to the fact that Africa has got poor infrastructure compared to many western countries it can easily adopt IoT for her smart cities [8] [7]. Businesses and individuals in Africa are expected to experience great impact of IoT. One such area that could

be revolutionized is medical care, where patients´ vital signs like blood pressure, temperature, oxygen levels among other parameters could be monitored easily and with high level of accuracy in real-time by use of chips implanted in their body; [7]. An example is in Ethiopia where patients taking antiretroviral are monitored automatically to measure the level of effectiveness and conformation [10], while in Malawi an mHealth application was introduced in 2013 that has sig-nificantly reduced child mortality in the poor country [11], [12]. Accenture a technology firm and Amref health African headquartered in Nairobi, Kenya, have recently partnered in a deal worth over $ 7.5 million to promote mHealth in Africa [9]. Money could be saved by incorporating IoT applications in everyday households generally connecting them and pooling essential data from each device which can then be used to make valuable information [7]. One area with a huge potential for Africa is precision Agriculture. Africa is said to have a quarter of the world arable land, unfortunately 80% of this is underutilized or simply lies idle, the majority of the remaining 20% is in the hands of small scale peasant farmers that have no idea how they can do commercial agriculture to improve production [12], [14]. In Nairobi, Kenya a simple application to automate agri-based veterinary shop called farm shop have seen the owners professionalize and automate their operations doubling the income and tripling growth in just over one year [14]. It is a simple ideas to automate all levels of small farm holders operations like the one proposed by a Ugandan agri-based developer that is expected to completely revolutionize the continents´ prospects [13]. There is generally high optimism in Africa, things seems to be looking up, just last week on 14th of July 2015, MTN Business one of the largest African telecom provider announced that they have launched an IoT platform specifically for African countries, According to Mteto Nyati, MTNs´ Group Enterprise Officer, the new IoT platform is dedicated to manage all the companys´ M2M functions [16], this is expected to spur up more activities in the continent, accelerate growth in various sectors and hopefully put the continent at par with the rest of the world who are already a step ahead enjoying the possibilities that is brought about by IoT, indeed many lives in Africa would be improved by adopting the new technology.

Fig. 1. IoT Schematic diagram showing Major Application Areas and targeted end users [60].

3. IOT CURRENT PROJECTS IN AFRICA

A. Usangu Logistics Limited in Tanzania

Using RFID to prevent oil pilferage by rogue drivers. Usangu Logistics (T) Ltd, is heavy transport company that has over 100 fleet of lorries and trucks dedicated to serving hundreds of their customers, the lorries and trucks not only offer transportation of oil, lubricants and other bulky products to various other organizations in Tanzania and beyond but also services the various petrol stations that are managed by Usangu Logistics [17]. The Immediate challenge that Usangu faced was that after the Tanker is loaded with the product for transport to various locations the drivers would often pilferage oil on the way to oil vendors for sale in the black market. Usangu did not have control over the drivers and did not know when, where and how much oil has been stolen along the way; this led to great loss to Usangu and their customers and prompted an immediate need for a solution that would help resolve the problem [18].

1) Technology before IoT based RFID: Currently, many logistics firms´ including Usangu Logistics´trucks before imple-menting the new technology uses a combination of lock system intertwined with a metal loop that is fitted around the closing mechanism of the tanks´ hatch. Only a driver in possession of the locks´ combination could open

the tank, It is almost impossible to remove the cap once the loop is locked; The system has no guarantee that the driver who is in possession of the locks´ combination could use it to pilferage oil to the black market before reaching his destination.

2) The new RFID based technology: An IoT based enabled gateway device is attached to the tracks cabin area, the seals that are also RFID enabled are fastens to the tracks´ hatch, the tag transmits signal to the gateway device at an average of every eight seconds the signal is sent to the back end software platform for interpretation and further action, typically the software will store the seal status and location of the track [18]. Now the tracks can be monitored in real-time and oil status and location be known at any given time, the gateway uses GPRS technology to communicate with the back end server. According to inbound logistics a company specialized in building and supplying shipment monitoring devices. The technology to monitor shipments has become really advanced in the past few years, this has resulted in possible prediction of devices to be used in future techniques to monitor and track shipments world over. The devices have made use of modern communication technologies like RFID, GPRS, Satellite, and GPS to develop state of the art M2M communications equipments that are now transforming the way shipments are handled world over. [19] The fact that these devices no longer depend on human interventions brings into reality the possibility of real-time monitoring of your goods and products regardless of where they are in the world. This is what Usangu discovered in 2011 and since then they have never regretted, it is believed that they have so far saved tidy amount of money as result of efficient management of their oil transport systems and flow. We hope many other companies could emulate what Usangu have done as the future of any businesses today depends largely on how best they utilize technology. Ultimately, knowing how to respond to the data collected matters most. Companies can turn information into action that can boost the bottom line and ensure a return on investment [19].

B. Republic of South Africa

Mr. Ran van Niekerk the Managing Director of Pan African technology company Metacom says that IoT began in South Africa over a decade ago, and has been shaping the country for the last ten years even without many people noticing it, he says the influence of IoT will continue to grow greatly in the coming few years as the real impact of the technology is felt across most industries, where as the terminology is new, South Africa has been building the technology for many years, he goes on to say that some notable activities includes building of nationwide network of sensors to connect everything among others electricity grids, traffic controls, etc. building of both public and private cloud infrastructures, industrial and commercial architectures among others [21]. At The beginning of 2012 The South African National Roads Agency Limited (SANRAL) introduced an e-tolling system in Gauteng highway. The e-tall system called the Open Road tolling is meant to collect tolls electronically without human intervention since there is no physical booths that have been erected on the highway, the system charges all vehicles using the highway without them slowing down or stopping. Simple overhead gantries are fitted with toll collection devices, the device has capability to recognize e-tag attached to the vehicles or the number plate as it passes through the gantries [21]. The vehicle owners are supposed to purchase e-tags and fit in their vehicles, the e-tags can also be loaded whenever the credit is over. In this IoT technology the traffic jam has been reduced dramatically while the Agency collects tolls for road maintenance. The tags can easily be purchased or loaded at picknpay stores around the country.

1) How the technology works: The vehicles owners are supposed to purchase e-tags at authorized stores countrywide and place the e-tag in the vehicles, as the vehicles drive under the gantry, the device installed at the gantry recognizes the registered e-tag making it to beep. There are cameras installed just within the gantry equipments and they take photos of the vehicles as its´ driven underneath the gantry. The software automatically identifies the vehicles class and dimensions, the user account is authenticated during the transaction by comparing the registered e-toll account details with the current information as transmitted by the gantry, some of the information that that gantry transmits includes number plate, e-tag details, vehicles class etc etc, fees are deducted automatically from the user e-toll account with strict monitoring of the transactions by the software and customer care representatives, if a problem arises customer care reps are suppose to be notified, all transaction details including invoices are accessible online [23]. South Africa seems to be getting ready for IoT compared to other countries in Africa; a Number of South African corporates are responding fast to IoT projects, just earlier this month MTN business announced that it was launching an IoT platforms to support IoT applications within the continent [16]. South Africa utility firm ESKOM implemented a utility management Application based on IoT, now people can tell where there will be black out and at what time and which municipality. This information is available online [24]. In the year 2010 Mereka Institute of Technology, a higher learning technology institution in South Africa constructed a panel to specifically spearhead research on IoT, [25].

Fig. 2. E-toll Management systems along Gauteng highway in South Africa [23].

C. Kenya: Waste Management System; an IoT Application developed by IBM for Nairobi County Government

Kenya is one of Africas´ first growing economies; it was recently declared a middle income country on 30th September, 2014 effectively claiming position nine of the top 10 countries in Africa ranked by Gross Domestic Product (GDP) [26]. The Country is also the financial hub of the East African region, indeed many large companies from developed countries wish-ing for East Africa pie have been rushing to set up their regional offices in Nairobi (Kenyas´ Capital city)[28]. Kenya Government has developed an ambitious economic blueprint, Vision 2030 is long term development policy adopted after extensive research to make Kenya an industrialized middle-income economy where her citizens would enjoy high quality of life in clean and secure environment. The vision is anchored on three key pillars namely Economic, Social and political. [29]. The ministry of ICT have spearheaded the development of Kenyas´ ICT master plan 2014-2017, that is anchored on the vision 2030 blue print to define the key sectors that ICT must be applied to rapidly accelerate the achievements of Vision 2030. The country has a very robust ICT infras-tructure with the internet penetration levels of about 47% according to Communications Authority data of 2012[30]. The most recent analysis by Communications Authority shows the country now have 80% mobile penetration meaning this same population have capacity to be connected to the internet by use of mobile phones [31]. Kenya as a country given her vast connection penetration should be ready for IoT, in fact a number of activities are on the pipeline, one of the interesting project is being done by Nairobi county council where by IBM have developed a sensor based devices installed in the councils lorries to effectively monitor the lorries for efficiency purposes. Nairobi county have been grappling with waste management for a long time now, in order to tackle this menace they have recently approached IBM research centre located in Nairobi to develop an IoT based application for waste management, basically the idea is to develop a solution that can be installed in waste collection fleet to monitor them in real-time, the application is also meant to create digital map for Nairobi streets. The Research being headed by Aisha Walcott Bryant will see the fleet of Lorries installed with smart devices that would tell when the vehicles were in garage, check dumpsite to report if they are full and needs to be drained, checks how long the lorry has taken in traffic, time they take to collect garbage among other things. This application is also expected to automatically monitor the drivers´ behavior, it will also be able to detect speed bumps, potholes at the same time check fuel usage by the driver, the smart devices also transmits data about the location of the lorries, altitude, speed, acceleration, orientation, vibration levels, humidity and temperature [32],[33]. Commenting on the project, Nairobi County Executive Committee Member for Environment Mr. Evans Ondieki, who has been instrumental to see the success of the project, said that the new technology will definitely give the city a new face. He continues to say that the Current IoT based initiative has enabled them to track the garbage fleet and ensure that the Lorries are doing their job at allotted time. He concludes by saying that from his office he can trace which lorry is doing what, and he has seen great improvements during the trial period as collected volumes have tremendously increased [32].

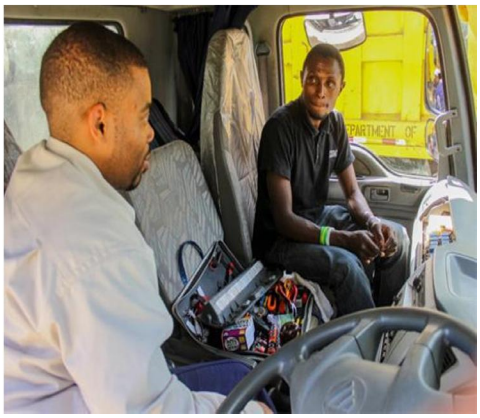

Fig. 3. IBM Research-Africa engineers Reginald Bryant (L) and Peter-Maina (R)installing sensor on a Nairobi Waste Management truck [33].

D. Nigeria

With about 48 million active internet users, Nigeria is one of Africas´ countries with huge market for IoT, the country has been building the infrastructure slowly from the year 2010 when it formulated national information communication technology strategic plan 2010-2015[34]. In the year 2013 Nigeria President Goodluck Jonathan launched a national broadband plan 2013-2018 with the goal of reaching all Nigerians both underserved and un-served in rural and urban centers., this underpins the importance the administration has put in using technology to grow their economy and serve all Nigerian

population[35]. While Nigeria is yet to see many IoT projects, just as in many other countries in Africa, the notable initiate was carried by NAFDAC. Faced with perennial counterfeiting problem Nigerias´ National Agency for Food and Drugs Administration and Control (NAFDAC) in 2010 resorted to product verification initiative using Radio Frequency Identification (RFID). The technology carried out in collaboration with Verification Technology Limited (VTL), will use tags equipped with RFID to secure the integrity of the drugs through out there supply chain starting from manufacturers, distributors, wholesalers, retailers and even consumers. The tags are expected to track down the drug paths as it moves over the supply chain. In order to verify drug authenticity special scanners will be put at the port of entry, it is also expected that other scanners will be purchased by hospitals, pharmacists and manufacturers to ensure collective effort in dealing with the problem [36].

E. Egypt

Things seems to be looking up in Egypt as far as IoT is concerned, Egypt have formed a steering committee to spearhead projects and solutions based on IoT. The committee is made up of senior officials from Government institutions, Academia and private sector. The committee has been meeting frequently and is already showcasing various interest areas on how IoT can be used to solve societal problems and create innovations [37]. Earlier this year Integreight, A Cairo based technology firm announced that it has developed IoT chip that can be integrated with day today gargets like fridges, cameras, Tvs, washing machine etc to manipulated them from the phone. The product named 1sheeld gives users capability to create an loT applications by simply connecting the chip to a Smartphone [42]

1) How the technology works: Using an Arduiono board (an open source electronic hardware and software platform for creation of interactive projects) [39], one places 1sheeld onto the board and opens the 1sheeld application from your Smartphone; you then connect to the board using Bluetooth. Using 1shield library you proceed to write the code on the arduiono software application before uploading to the board. This then is used to control many sensors that are available in the board [40]. There are other proposals underway including using sensors to undertake precision potato farming, bee keeping among others [41], indeed Egypt seems to have taken lead role in spearheading IoT activities in Africa.

F. Namibia

The small South Western African nation is not being left behind, recently in order to improve effectiveness of an-tiretroviral drugs implementing an electronic dispensing tool (EDT). In order to dispense correct medicines in correct amounts, pharmacists usually require to have some minimal information about the patients such as medical history, this is necessary if the patient is to get optimized care and for the pharmaceutical providers effective management of stock including timely decision making. Getting this information has been a great challenge hence the innovation of an EDT. An EDT helps pharmaceutical providers to collect, manage and generate necessary data that are useful for accurate dispensa-tion of medicine. Among the data collected includes patients profile, medicine inventory and patients statistics needed for management decisions [42], The EDT devices can do among other things; Manage stock both incoming and outgoing stock, alerts patients of upcoming appointments using SMS, allows users to work on the same database at the same time, build in reporting tool for used medicines, allows customized reporting functions among many others.

G. The Rest of Africa

Many other countries in Africa are not ready for IoT in fact they seem to have heard nothing about the term itself, Other countries like Tunisia, Rwanda and Algeria setting up budgets to spruce up their ict infrastructure, in September 2012 International Telecommunication Union (ITU) organized an IoT workshop in Hammamet Tunisia to discuss the progress of IoT [43]. It is no doubt that Africa needs an urgent awareness especially to the government of respective countries to take up leading role in this new technology. Some other IoT initiatives taking place around Africa includes:

a) Internet.org: Launched in 2014 by Facebook CEO Mark Zuckerberg, with the aim of connecting the unconnected, internet.org is working with several developers and telecom providers to connect millions of people currently with focus on Africa and Asia. This will help in spearheading connections of things among the unconnected [50]. Think is a technology in-cubator company based in Kigali Rwanda that was established in 2014 to empower, support and fund exceptional technology innovations in order to fast track the launch of innovative digital solutions that solve Africa problems [51].

b) BRCK: has been developed by a team of software developers, engineers and technologists based in Nairobi Kenya. The same group have build other things including Ushahidi, Crowdmap and the iHub. The BRCK was designed and prototyped in Nairobi, Kenya. According the BRCKS Team they wanted to build a device that can withstand chal-lenges among them connectivity problematic

electricity and internet connections in both urban and rural areas [52]. BRCK makes accessing the internet simple and reliable wherever you are. Its´ a rugged, cloud-managed, full-featured modem/ router with built in fail-overs and programmable general-purpose input/output (GPIO) expansion. If theres´ a way for you to connect, BRCK will help you get up, and stay up, no matter where you are. In essence, BRCK is breaking the connectivity barrier in Africa, one router at a time [49]. Gust Pay is an IoT startup that enhances the user experience by use of near field communication (NFC) wristbands and a mobile application to cut entry queues, improve bar service efficiency, provide real time analytics and able to do push marketing.

4. CHALLENGES FACING IOT ADOPTION IN AFRICA

Earlier in July this year, while launching IoT application platform in South Africa, Africas´ largest telecom operator MTN Business brought to the continent what is believed to be the world technology game changer. Africa having almost all countries with developing economies is believed to be the continent that may eventually benefit the most in adopting applications developed with IoT platforms; it will change peoples´ lives forever, improving processes, services, channel deliveries among others. MTN says that IoT is a cutting edge technology that is suited to developing markets, bringing with it flexible connectivity for devices across the region [44]. In his presentations to IoT week in June 2013, Dr. Louise Coetzee of CSIR Meraka summarized the challenges of IoT uptake in Africa in three dimensions namely: Context, Technology and Applications [46]. Under context Dr. Coetzee explains that the following challenges have been identified; governance, policy frameworks, data security and peoples´ privacy, business models and ethical issues. He goes on to classify technology challenges as things to do with Access, infrastructures, interoperability, commercially off the shelves (COTS), scale and standards. He concludes that metadata; deluge data, scale and trusts issues are some of the notable application challenges facing IoT uptakes in Africa [46]. In summery Africa needs to continue building up her infrastruc-ture to increase it from the current 10% internet penetration to connect as many people as possible as IoT depends entirely on robust infrastructure and connections; many countries in Africa are already doing this through mobile connections [47]. It is important to note that even with these challenges there are also myriad opportunities according to Dr Coetzee, such includes sustainability, economic growth and industry applications [46], and he says that IoT can be applied in almost all industries to alleviate poverty, improve quality of life and preserve our environments. In such, we must balance between challenges and opportunities to get optimized rewards from IoT in Africa.

5. CONCLUSION

Imagining how the world will look like with Twenty-six billion connected devices by 2020 and over 1.9trillion dollars annual revenue added to the global economy, the Gartner projection of IoT is breath taking, from self managing parking lots, tires warning drivers of low pressure, lights regulating based on owners moods, precision Agriculture etc the next few years will see our lives dramatically changed for better as a result of IoT [48]. As everyone scramble to have a piece of IoT; there become apparent many hurdles and challenges that must be overcome for the dream to become a reality. Africa stands out as a unique situation. On the one hand, the continent as a whole has very poor internet penetration; 26.5% compared to a global average of 42.3% in 2014, based on world internet statistics by end of 2014 [47]. According to Anne Bouverot, GSMAs´ Director General ”In Africa sometimes you can al-ways leapfrog and implement latest technology and innovation at the same time regardless of where your current level of technology is.” [45]. With Every Challenge lies opportunity for example while Africa is lagging behind in building infrastruc-ture, most internet networks around the world are not geared towards supporting M2M data hence as many of the developed nations in Europe and Americas are forced to re-organize their networks to support IoT; Africa could leap ahead by building networks and infrastructure that supports M2M data at the same time implement IoT based solutions and investments that would see it enjoy greater benefits compared to developed nations [49]. What Africa needs is to immediately push on various research activities and innovations to run parallel with connections and applications and within no time, Africa will definitely be the bedrock of IoT innovations and utilizations. As the opportunities brought about by connected devices in overcoming hurdles and challenges becomes clearer; IoT uptake in Africas´ is bound to skyrocket in the coming years. We have discussed the various impacts of such simple IoT devices in various countries and their capacity to better lives of Africas´ Billion Population, we can´t wait to see the real impact trickling down to remote villages of Africa and the joy it would bring.

REFERENCES

[1] http://www.ft.com/cms/s/0/2bcfba68-2a17-11e5-acfb-cbd2e1c81cca. htmln#axzz3gDiDuSV4

[2] http://www.independent.co.uk/life-style/gadgets-and-tech/news/-huawei-chinas-apple-launches-internet-of-things-platform-to-power-cars-and-houses-10264022.html
[3] http://www.zdnet.com/article/south-korea-to-invest-5b-by-2020-in-iot-and-smart-cars/
[4] http://www.pewglobal.org/2014/02/13/emerging-nations-embrace-internet-mobile-technology/
[5] http://www.muthonimasinde.net/?page id=36
[6] Masinde, M, 2014. IoT Applications that work for the African Continent: Innovation or Adoption?, In: 12th IEEE International Conference on Industrial Informatics (INDIN 2014) Proceedings, held in Porto Alegre, Brazil 27-30 July 2014.
[7] http://africanbusinessmagazine.com/sector-reports/infrastructure/will-africa-take-lead-internet-things/n#sthash.g4S1vtuG.dpuf
[8] Lions go digital:- The internet transformative potential in Africa by Mkinsey Global Institute (GBI), 2013 report.
[9] ptmonguidelinesfinalv1,http://www.who.int/3by5/capacity/ptmonguidelinesfinalv1.PDF
[10] http://www.machinetomachinemagazine.com/2015/03/09/accenture-amref-to-improve-mhealth-in-africa/
[11] http://www.villagereach.org/2015/03/26/scaling-mhealth-in-malawi-something-to-celebrate/ (accessed on 20/7/2015, 7:20 Am)
[12] http://adc.bmj.com/content/96/Suppl 1/A74.3.abstract
[13] https://ideas.itu.int/post/73105 (accessed on 20/7/2015 8:00 Am
[14] http://www.bbc.com/future/story/20130408-tech-taps-africas-farm-potential (accessed on 20/7/2015).
[15] Wi-fe backscatter:- Internet connectivity for RF powered devices, Bryce Kellogg, Aaron Parks, Shyamnath Gollakota, Joshua R. Smith, and David Wetherall University of Washingtonkellogg, anparks, gshyam, jrsjrs, djw@uw.edu
[16] http://www.itnewsafrica.com/2015/05/mtn-business-launches-pan-african-internet-of-things-platform/
[17] http://www.usangu.co.tz/
[18] http://www.rfidjournal.com/articles/view?8255
[19] http://www.inboundlogistics.com/cms/article/shipment-monitoring-technology-picking-up-the-signals/
[20] http://www.itwebafrica.com/network/333-africa/233847-does-africa-get-the-internet-of-things?
[21] http://www.itweb.co.za/index.php?option=com content&view=article& id=142250
[22] http://www.picknpay.co.za/sanral
[23] http://www.sanral.co.za/etoll/index.php?gort xml+template menu/ main L1 2073 ENG
[24] http://loadshedding.eskom.co.za/loadshedding/description
[25] http://euroafrica-ict.org/wp-content/plugins/alcyonis-eventagenda//files/ Internet of things engineering group.pdf
[26] http://www.forbes.com/sites/faraigundan/2014/10/01/kenya-joins-africas-top-10-economies-after-rebasing-of-its-gross-domestic-product/
[27] Kenya National ICT master plan 2014-2017
[28] http://www.trademarksa.org/news/multinationals-now-turning-nairobi-hub-africa
[29] http://www.vision2030.go.ke/wpcontent/uploads/2015/06/Vision2030 Popular version final2.pdf
[30] http://www.internetworldstats.com/africa.htm
[31] http://www.ca.go.ke/index.php/what-we-do/94-news/285-kenya-s-mobile-penetration-hits-80-per-cent
[32] http://cio.co.ke/news/main-stories/data-collection-technology-by-ibm-research-africa-to-curb-garbage-menace-in-nairobi
[33] http://ibmresearchnews.blogspot.com/
[34] http://www.vanguardngr.com/2014/10/nigeria-48m-active-internet-users-nitda/
[35] http://www.researchictafrica.net/countries/nigeria/Nigeria National Broadband Plan 2013-2018.pdf
[36] http://www.secureidnews.com/news-item/nigeria-reduces-drug-counterfeiting-with-the-aid-of-rfid/
[37] http://iot-egypt.com/steering-committee/
[38] http://www.mcit.gov.eg/Media Center/Latest News/News/3427
[39] https://www.arduino.cc/en/Guide/Introduction
[40] http://techreviewpanarab.com/en/mobile/n%D8n%A5n%D9n%86n %D8n%AAn%D8n%B1n%D9n%86n%D8n%AA-n%D8n%A7n%D9n %84n%D8n%A3n%D8n%B4n%D9n%8An%D8n%A7n%D8n%A1/
[41] http://www.sciencedirect.com/science/article/pii/S111086651300025X
[42] http://siapsprogram.org/tools-and-guidance/edt/
[43] http://euroafrica-ict.org/wp-content/plugins/alcyonis-event-agenda/ /files/PROBE-In%28on%29T---Probing-EU-Africa-Cooperation-on-Internet-of-Things.pdf
[44] http://afkinsider.com/99459/is-africa-ready-for-the-internet-of-things-mtn-think-so/
[45] http://www.theafricareport.com/North-Africa/technology-africa-fast-off-blocks-in-adopting-internet-of-things-industry-grou.html
[46] http://media.iot-week.eu/2014/12/South Africa.pdf
[47] http://www.internetworldstats.com/stats.htm
[48] http://www.gartner.com/newsroom/id/2636073
[49] http://www.howwemadeitinafrica.com/needs-based-innovation-can-catapult-africa-to-the-forefront-of-iot-innovation/49256/
[50] https://www.internet.org/platform
[51] http://www.think.rw/n#about-us
[52] https://www.brck.com/about/
[53] https://www.gustpay.com/
[54] https://www.cisco.com/web/about/ac79/docs/innov/IoT IBSG 0411FINAL.pdf
[55] http://newsroom.cisco.com/featurecontent?type=webcontent&articleId=1208342
[56] http://arxiv.org/ftp/arxiv/papers/1207/1207.0203.pdf
[57] http://www.mckinsey.com/insights/high tech telecoms internet/the internet of things
[58] http://www.itu.int/itunews/manager/display.asp?lang=en&year=2005&issue=09&ipage=things
[59] http://www.networkworld.com/article/2287045/wireless/153629-10-most-powerful-Internet-of-Things-companies.htmln#slide1
[60] http://dl.acm.org/citation.cfm?id=2489456