

STATE OF INTERNET OF THINGS DEPLOYMENT IN AFRICA AND ITS FUTURE: THE NIGERIAN SCENARIO¹

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INTRODUCTION

Internet of things (IoT) refers to an intelligent network of connected objects for the purpose of communication, actuation, data aggregation and information processing. Currently in Africa there is a slow rate of adoption of IoT compared with other continents. Nigeria, as the biggest mobile market and most populous African country, has enormous prospects in IoT, which if effectively implemented, is likely to bring about increased productivity across all economic sectors and an improved standard of living for the people. This paper looks at the current state of IoT deployment in Nigeria, the challenges faced and the opportunities that abound.

SUCCESS FACTORS FOR IOT DEPLOYMENT IN NIGERIA

With seven mobile operators and a population of about 170 million people, Nigeria had 85 million subscribers as at June 2015, and is the largest mobile market in the Economic Community of West African States (ECOWAS), accounting for more than half of the sub-region's subscriber base [1]. One of the success factors affecting the deployment of IoT in Nigeria is the low cost of electronic components and services. Sensor prices have dropped to an average of 60 cents from USD1.30 in the past 10 years, while the cost of bandwidth has also declined steeply, by a factor of nearly 40 times over the past 10 years [2]. In like manner, the cost of processing has seen a sharp decrease of nearly 60 times in the past 10 years, thereby allowing more devices to smartly handle all the new data they are generating or receiving. With the recent introduction of big data analytics, the millions of data sets turned out daily by the various connected "things" in the IoT network can be processed faster and better. New technologies for energy conservation, such as energy harvesting and ultra-low power devices, are a key enabler for IoT, as they assure a reduced power requirement in areas like Nigeria where power supply is unreliable and sometimes infrequent.

STATE OF IoT DEPLOYMENT IN NIGERIA

According to the National Information Technology Development Agency (NITDA), the prime agency for national development of information technology (IT) in Nigeria, IT used in all economic sectors currently contributes about 11% to the gross domestic product (GDP) of Nigeria and has the potential of increasing to between 17 and 20% by the first quarter of 2016 [3]. This can be achieved with Nigeria's commitment to the development of Internet of Things and Machine-to-Machine connections. Such commitment has been indicated by Nigeria's decision to be the Official Country Partner for Africa at the Gulf Information Technology Exhibition (GITEX) in 2014 [4].

A recent research survey reports that only 30% of enterprises in Nigeria have implemented Machine-to-Machine (M2M) technology, a subset of Internet of Things, in some form or the other, with security monitoring, fleet management and point-of-sale machines currently accounting for the majority of M2M connections in Nigeria [5]. Advanced M2M applications such as smart metering, pay-as-you-drive insurance and intelligence building are not currently widely used in Nigeria, with connectivity and the complexities involved in implementing and managing such technologies serving as the key inhibitors [6].

One of the most common forms of M2M adoption in the country is car tracking and fleet management. Companies, including MTN and Vodacom Business Nigeria, offer services in these fields with features such as real-time tracking over maps, fuel level and consumption monitoring, geo-fencing, web-based access and report download, among others [7] [8]. An economic security application of IoT is the tracking of oil tankers and vessels by the Nigerian National Petroleum Corporation (NNPC). With vehicle tracking and fleet management solutions, the Corporation now has the ability to monitor vessels from the loading port to the discharge port, know their travelling speeds, the exact coordinates, destination and expected time of arrival [9].

Another form of M2M adoption in Nigeria is visible in the fight against fake and substandard medicinal drugs and pharmaceuticals by the National Agency for Food and Drug Administration and Control (NAFDAC). The agency has deployed technologies such as TruScan, Black Eye, Radio Frequency Identification (RFID), Mini Lab and Mobile Authentication Service in the fight against fake medicinal drugs and pharmaceuticals. While TruScan is a hand-held device for on-the-spot detection of counterfeit medicines, Black Eye is bench-top equipment using infrared technology to detect fake medicines. On its part, the RFID is used for verification of regulated products and other sensitive documents. The MAS technology is also known as Scratch and Text Messaging System. It enables consumers to confirm whether the drug they intend to purchase is genuine or not, through the use of a mobile phone. The Mini-Lab test kit is a reliable, simple and inexpensive method of detecting counterfeit medicines [10].

Furthermore, as part of an ambitious strategy to transform agriculture, the Growth Enhancement Support (GES) initiative, introduced in 2012, uses farmers' cellphones as electronic wallets – distributing vouchers amounting to a 50%

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subsidy for purchase of fertiliser. Ministry officials say the phones could eventually be used for multiple purposes, from communicating weather and climate information to accessing market data. Experiences in other African countries show that such uses can deliver higher prices to farmers. Records also show that 1.2 million farmers received their subsidised fertiliser and seeds through cellphone vouchers in 2013, resulting in the addition of 8.1 million metric tons to Nigeria's domestic food supply. As a result, Nigeria reduced its food imports by over 40% by 2013, moving the country closer to self-sufficiency in agriculture [11].

Another way in which M2M connectivity is experienced in Nigeria is in the deployment of point-of-sale (PoS) terminals. A PoS terminal is an electronic device that is used for verifying and processing credit card transactions, which transmits data over a standard telephone line or an Internet connection. The Nigeria Interbank Settlement Services (NIBSS) had observed in its recent report that PoS is the most popular non-cash payment channel, preferred among the non-cash payment options by 93.6% cent of merchants and 35.8% cent of consumer usage. It described the usage of card and PoS as fair, with an average of three to four out of every 10 customers requesting to pay for transactions by card/PoS. However, the report said only 3.1% of consumers cited card/PoS as their preferred payment option, attesting to the low usage of PoS [12]. Electronic payment through PoS terminals has risen by 191 percent to N241 billion in 2014 [13].

The PCB and Microelectronics Centre, a department under the Nigerian Satellite Company Limited (NigComSat), has successfully designed, implemented, tested and deployed an RFID-based Staff Attendance and Access Control System (RFID-SAACS). RFID-SAACS is a vital tool for staff management, administration, and monitoring that will impact on staff attitude to work, as time theft by staff will be completely eliminated. The logged data can also serve as a means of staff monthly appraisal, while an additional utilisation of the RFID-SAACS system includes integration into the payroll system to facilitate precise salary computation and payment based upon vetting of employees' overall performance [14].

One of the most important applications of IoT in Nigeria was the use of RFID cards and readers in the 2015 general elections. The technology was used to check the authenticity of voters in the elections and greatly improved the credibility of the process by its ability to detect fake and cloned Permanent Voter Cards (PVCs), thus curbing massive thumb printing and the undemocratic and unconstitutional culture of political parties purchasing PVCs from voters with the aim of committing electoral fraud [15].

An important application of the Internet of Things to Nigeria is the use of Unmanned Aerial Vehicles (UAVs) in the fight against terrorism. Nigerian military sources have singled out the use of drones in the fight against Boko Haram as one of the most important factors in the recent victories of the military. The drones are said to have enhanced the surveillance capability of the army by providing real time transmission of the battlefield and in helping with the identification of terrorist camps [16] [17].

Another use of UAVs is in the fight against oil theft and pipeline vandalism. Nigeria loses 50,000 barrels of crude oil to oil theft every day, and has lost no fewer than 360 combined staff of the Nigerian National Petroleum Corporation (NNPC), the Nigerian Police and members of the community to oil theft in one year. The NNPC plans to incorporate drones as part of its measures to check the movement of vessels within Nigerian territorial waters. This measure is aimed at enhancing transparency and accountability in the oil and gas industry, as well as to boost production capacity in the sector [18].

In order to meet the diverse needs of drones in Nigeria, the Nigerian Airforce (NAF) unveiled Nigeria's first Indigenous Unmanned Aerial Vehicle (IUAV) to combat insecurity in the country. The IUAV, code named "Gulma", is capable of performing both military and civil roles such as surveillance, disaster management, convoy protection and maritime patrol. It is also capable of performing policing operations, pipeline and power line monitoring, border patrol and weather forecasting [19].

Other deployments of M2M connectivity in Nigeria include the use of pre-paid meters in the electricity industry. The benefits of the meter include an increase in revenue to the electricity company by reducing the overheads that usually characterise house-to-house recovery of revenues, and by also reducing administration cost required in its deployment. It helps the electricity company to determine the actual energy demand, while giving fair bills, control and reliable electricity to consumers [20].

Mobile phones have been used to help teachers improve English language literacy among primary school students in Nigeria. The project was launched by UNESCO and Nokia in 2013, with support from the British Council and the National Teachers' Institute of Nigeria. Participating teachers signed up for a mobile service called "English Teacher", which sends teachers educational content and messages with pedagogical advice once a day. The messages are organised into thematic modules and include images and exercises. The service runs on the popular Nokia Life+ platform and is one of the first attempts to employ mobile technology as tools for primary school teachers [21].

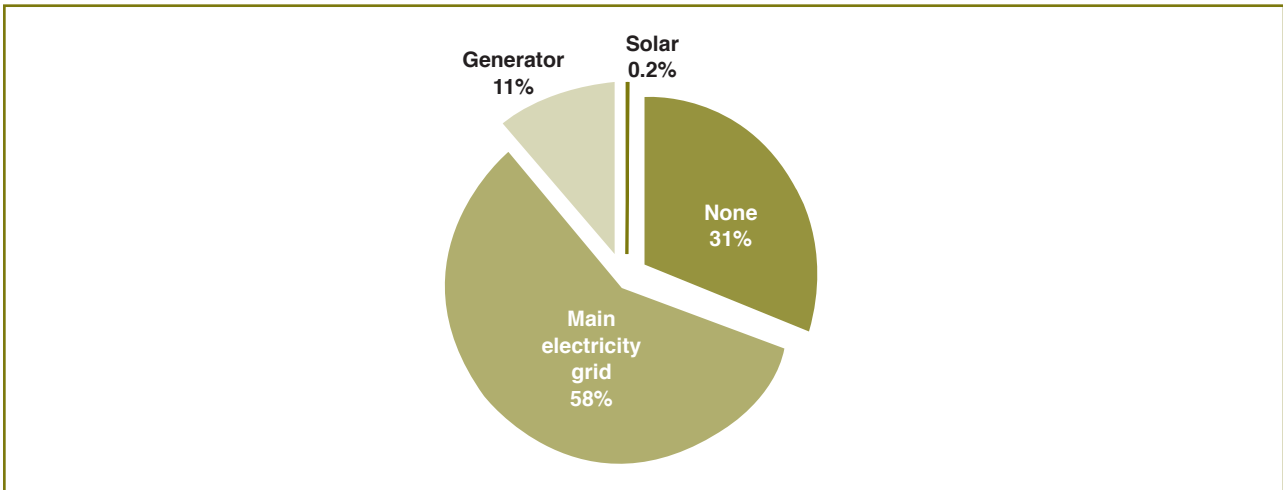
CHALLENGES TO THE DEPLOYMENT OF INTERNET OF THINGS AND MACHINE-TO-MACHINE CONNECTIONS IN NIGERIA

With respect to IoT deployment in Nigeria, most applications are at the nascent and experimental stages and there has not been a full technical and industrial grasp of its numerous opportunities due to several challenges. One of the main challenges to the deployment of IoT and M2M technology in Nigeria is the poor quality of service from network providers.

While there is little doubt that electronic communications is playing an increasingly critical role in the economic development of Nigeria, there are currently incessant complaints from customers on poor quality of service (QoS) [22]. The International Data Corporation (IDC) believes that connectivity will be a major driver for the future adoption of M2M and the Internet of Things (IoT) in Nigeria [5].

Another limitation to the growth of IoT and M2M in Nigeria is poor power supply. The Nigerian Association of Energy Economists (NAEE) has noted that despite statistics indicating that 45% of Nigeria’s population is currently connected to the national grid, regular supply is still restricted to about 25% of the population [23] [24]. Nigeria’s power generation capacity is markedly low compared to the estimated demand of 12,800MW. Nearly a third of the households surveyed by ResearchICTAfrica (RIA) in Nigeria are not connected to the national electricity grid, as shown in Fig. 1, while eleven percent of households surveyed depend primarily on generators for power [25].

FIGURE 1: HOUSEHOLD ELECTRICITY ACCESS IN NIGERIA [25]



Low access to personal computers and the Internet is another challenge facing the development of IoT and M2M connections in Nigeria. The results of the demand-side RIA Household and Individual ICT Access and Usage Survey for 2012 show that the majority of households in Nigeria continue to be excluded from the full range of communication services. Radio (69.5%) and TV (53%) have the greatest penetration at household level in Nigeria, and fixed telephony (0.3%) and dedicated household Internet (3.4%) are the least-accessed ICT tools [25], as Table 1 shows.

TABLE 1 NIGERIAN HOUSEHOLD ACCESS TO ICT [25]

	Number of households	% of households
Radio	15,270,063	69.5
TV (free-to-air	11,644,796	53
Satellite/cable TV decoder (subscription)	2,834,299	12.9
Desktop PCs and laptops	1,450,107	6.6
Mobile telephone	1,054,623	4.8
Fixed household internet	747,025	3.4
Fixed telephone	65,914	0.3

Digital illiteracy also poses a barrier to the adoption of IoT in Nigeria. In a survey done by Insights Africa on the barriers to Internet usage, lack of knowledge and connection/access were rated as the highest barriers [26]. This illustrates that many people do not use the Internet due to lack of knowledge on Internet use, rather than the cost of it. The high rate of poverty is another limiting factor. Despite the fact that the Nigerian economy is growing, paradoxically, the proportion of Nigerians living in poverty is increasing every year [27].

Future challenges that Nigeria and its industry players will have to address is supplying the technical capacity and people expertise to meet the future boom in the IoT-enabled market. Expertise will be needed in the areas of data mining, big data analytics, wireless sensor connectivity and cloud computing, among others. There will also be new challenges for policy and regulation to contend with.

CONCLUSION: OPPORTUNITIES IN VARIOUS SECTORS OF THE NIGERIAN ECONOMY

Nigeria is presented with challenges in many sectors of the economy, with respect to which IoT can go a long way to alleviate specific problems. Table 2 below is a brief overview of a few topical areas in specific sectors and how IoT can help improve economic performance and social wellbeing.

TABLE 2: PROFFERING IOT SOLUTIONS TO PRESSING ISSUES IN VARIOUS SECTORS OF NIGERIAN ECONOMY

S/N	SECTOR	AREAS OF APPLICATION	STATISTICS/ISSUES OF ATTENTION (ALL IN NIGERIA)	BENEFITS OF IMPLEMENTATION
1	Healthcare	Crowd control + Critical patient monitoring + Tracking of drugs and medical equipment	At least 16 persons lost their lives due to a stampede and many were injured at the Nigerian immigration recruitment exercise in 2014 [28]	Avoidance of death and injury caused by stampede and suffocation in crowded environment. Effective emergency response through best route received from real-time traffic data
2	Transport	Accident avoidance + Traffic monitoring	Between 2006 and 2013 the FRSC recorded 41,118 deaths from road accidents, of which 2,061 in 2013 (74% of accidents resulted in fatalities) [29]	Vehicles provide road safety by monitoring and sensing each other. Monitoring traffic jams through cell phones of the users and deployment of intelligent transport systems (ITS) will help to reduce traffic jams.
3	Oil Industry	Pipeline monitoring	FG and oil companies operating in the Niger-Delta region lost USD14 billion dollars to pipeline vandalism in the year 2014 [30] 51,500 hectares of land devastated by spills in 2014 [30] In 2015, Nigeria's total electricity generation dropped from about 4500MW to 2800 MW due to pipeline vandalism [31] About 60,000 barrels of crude oil and condensate per day are lost through petroleum pipeline vandalism and sabotage [32]	Fight against vandalism, oil spillage and oil bunkering and tracking of vessels and equipment.
4	Security	Military intelligence + Surveillance	Nigeria ranked 4th in the Global Terrorism Index with 303 terrorism incidents, 1,826 fatalities and 457 injuries. Cost of the insurgency to the national economy was estimated at USD28.48 billion [33] 73.3% of business has partially closed operations in northern Nigeria because of this insecurity [34].	Drones with a connected camera and a large wide range can send thousands of images of a dangerous field.
5	Energy and Utilities	Smart metering + Automatic reservoir systems	Electricity supply at 4,306MW, far below the estimated demand of 12,800MW [24]. Only 40 percent of the population have access to electricity [24]. Nigeria is losing about N65 billion annually to electricity wastages due to lapses in distribution and consumers' nonchalance [35].	Reduction of wastage of energy through smart metering.
6	Agriculture/ Environment	Product marketing + Wildlife conservation + Nomadic herding	48 species of animals in Nigeria are endangered; 16 species categorised as rare; 30 species as vulnerable [36].	Fulani or Maasai herdsmen can track the movement of their cattle in real time and get the best grazing advice from weather apps. Avoidance of conflict between nomadic communities at meeting points. Precision agriculture helps farmers maximise resources like water, increase yield and market their produce directly to consumers. Accurate identification of animals aids disease control.
7	Waste management	Recycling + Waste disposal	Most cities spend 20-50% of their annual budget on solid waste management and only 20-80% of the waste is collected [37].	Monitoring of vehicle emissions to help supervision of air quality, the collection of recyclable materials and the reuse of packaging resources and electronic parts to avoid waste.

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