



Leveraging Internet of Things for National Development

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Abstract This paper explores the current use and potential of Internet of Things (IoT) technologies in tackling National development challenges. The Internet of Things is becoming a very popular concept in the technology industry today, with many different useful applications. The IoT application covers “smart” environments/spaces in domains such as: Transportation, Building, City, Lifestyle, Retail, Agriculture, Factory, Supply chain, Emergency, Healthcare, User interaction, Culture and tourism, Environment and Energy. All these applications are very useful to the world today, and they solve a lot of problems and generally make life easier. In addition, the paper highlights some of the challenges to the deployment of IoT in Nigeria. The paper recommends that policies should be put in place at the national level to support and facilitate the fast development of IoT, as well as eliminate the barriers and challenges, and efforts should be made to improve the quality of service offered by network providers in order to increase the speed of the Internet access.

Keywords IoT, National development, Income growth, Smart environment, Technology

Introduction

The 21st century is the most interesting century of all the humankind’s history. Almost every section of human activity has changed and improved significantly. This century is characterised by the technological innovation, and has become the age of globalization. In this century, the Internet of Things is becoming a very popular concept in the technology industry with many different useful applications. The phrase Internet of Things refers to the comprehensive network that consists of interconnected smart objects. These smart objects, services, people, and devices can exchange data and information, as well as communicate in order to attain common goals in different areas and applications. The goal of Internet of Things is to enable objects to be connected anytime, anyplace, with anything and anyone.

Although there is no unique definition available for Internet of Things that is acceptable by the world community of users, it can be defined as an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment [1]. There are many other different groups including but not limited to academicians, researchers, innovators, and developers that have defined the phrase, although its initial use has been linked to Kevin Ashton, an expert on digital innovation. What all of the definitions have in common is the idea that the first version of the Internet was about data created by people, while the next version is about data created by things. Internet of things is an internet of three things: people to people, people to machine/things, and things/machine to things/machine, interacting through internet [2].

Internet of things promises many applications in human life, making life easier, safe and smart. There are many applications such as smart cities, homes, transportation, energy and smart environment. Connecting these systems online has various advantages; they become easier to use, processes are automated, devices can be controlled remotely, the level of physical security becomes increased as a result of automation, etc [3].



Today, governments, businesses, organizations, industries, health centres and consumers are using the IoT to introduce new business models, to improve the delivery of services, to increase efficiency in production, and to enhance wellbeing and human welfare. This paper explores the current use and potential of Internet of Things (IoT) technologies in resolving National development challenges. In addition, the paper highlights some of the challenges to the deployment of IoT in Nigeria. Finally, it presents summary recommendations on what is required for the IoT to reach millions of people living in Nigeria, and also to accelerate income growth and social development as a result.

Applications of IoT across Different Sectors

The IoT application covers “smart” environments/spaces in domains such as: Transportation, Building, City, Lifestyle, Retail, Agriculture, Factory, Supply chain, Emergency, Healthcare, User interaction, Culture and tourism, Environment and Energy. IoT application across different sectors are discussed below.

i. IoT in Automotive Industry

Advanced cars, trains, buses as well as bicycles are becoming equipped with advanced sensors, actuators with increased processing powers. Applications in the automotive industry include the use of smart things to monitor and report various parameters from pressure in tyres to proximity of other vehicles [4]. The devices attached to the parts of vehicles contain information related to the name of the manufacturer and when and where the product was made, its serial number, type, product code, and in some applications the precise location in the facility at that moment. The IoT permits many things to be connected, tracked and monitored so that meaningful information and private data can be collected and analysed automatically [5].

ii. IoT in Healthcare

In health care domain, remote patient medical monitoring and advanced medical diagnosis is possible using IoT. Tracking the staff, patients and objects is under control. Identification and authentication of people, automatic data collection and sensing is carried out for remote monitoring of patients from diverse geographical locations [6]. In terms of preventative care, IoT fitness devices such as Fitbits, and movement sensors are now built into many new smart phones, enable many individuals to monitor and track themselves, which generally promotes healthier lifestyles. For example, Apple and Google have added features to their latest smart phone operating systems to integrate health sensor devices and promote users to monitor their own health data using non-specialist health tracking apps [7].

iii. IoT in Agriculture

In agriculture, IoT technologies can be used to increase, protect, and optimize crop production, as well as improve the storage and distribution of food. Growth in agricultural productivity over the last fifty years has been much slower in developing regions of the world, in part due to large capital costs [7]. Similarly, gathering and utilizing local weather data, a critical aspect of farming, remains a major challenge in developing regions due to limited coverage. Traditional weather monitoring equipment is large and capital-intensive, but the IoT is now allowing for micro-weather stations to be deployed and utilized for a range of activities, including the dissemination of information to farmers on nutrient requirements, the prediction of weather patterns, and the provision of inputs into localized crop insurance schemes [7]. Another example includes the use of RFID tags for monitoring livestock, which allows for more personalized care for individual animals.

iv. IoT in Transportation and Logistics

By the technology of Internet of Things, it is possible to track the location and the status of an object throughout the full product life-cycle and throughout the supply chain. First of all, sensors can be used to make sure that the products were never exposed to damaging environments [6]. Monitoring traffic jams through cell phones of the users and deployment of intelligent transport systems (ITS) will make the transportation of goods and people more efficient. Transportation companies would become more efficient in packing containers since the containers can self-scan and weigh themselves. Use of IoT technologies for managing passenger luggage in



airports and airline operations will enable automated tracking and sorting, increased per-bag read rates, and increased security [4].

v. IoT in Homes and Offices

Sensors and actuators distributed in houses and offices can make our life more comfortable in several aspects: rooms heating can be adapted to our preferences and to the weather; the room lighting can change according to the time of the day; domestic incidents can be avoided with appropriate monitoring and alarm systems; and energy can be saved by automatically switching off the electrical equipments when not needed [8]. In the smart home, many devices are connected and smartly shares information using a home network. Consequently, there exists a home gateway that controls the flow of information among smart devices connected to the external network.

vi. IoT in other Sectors

Examples of IoT deployment impacting other facets of global development abound, and the opportunities to improve service delivery, and other aspects of development work, are limited only by human creativity and the resources available [7]. Table 1 below highlights some of the various IoT interventions as they map to the Millennium Development Goals (MDGs) and the new Sustainable Development Goals (SDGs) as adopted by the United Nations.

Table 1: Examples of IoT interventions mapped to the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) [7]

SECTOR	MDG	SDG	EXAMPLES
Health, Water & Sanitation	MDG 4: Child Health	SDG 3: Ensure healthy lives and promote well-being for all at all ages.	i. Sensor- and SMS-enabled village water pumps (Rwanda, Kenya);
	MDG 5: Maternal health		ii. GSM-connected refrigeration for vaccine delivery in the ‘cold chain’ (Global);
	MDG 6: Combat HIV/AIDS, malaria and other diseases	SDG 6: Ensure availability and sustainable management of water and sanitation for all.	iii. sensor enabled ‘band aid’ to monitor Ebola patients’ ECG, heart rate, oxygen saturation, body temperature, respiratory rate and position, all remotely (West Africa);
			iv. water stream gauge with sonar range sensor to monitor river flow and depth (Honduras);
			v. water flow sensors and motion detectors in latrines to monitor efficacy of hygiene training and intervention (Indonesia).
Agriculture & Livelihoods	MDG 1: End Poverty & Hunger	SDG 1: End poverty in all its forms everywhere.	i. Connected micro-weather stations improving localized weather data and provision of crop failure insurance (Kenya);
		SDG 8: Promote sustained, inclusive and sustainable economic growth, and productive employment and decent work for all.	ii. low-cost mobile-controlled micro irrigation pumps (India); soil-monitoring sensors used to improve tea plantation production (Sri Lanka, Rwanda);
		SDG 2: End hunger, achieve food security, improve nutrition, and Promote sustainable agriculture.	iii. RFID-based food supply testing and tracking system (India) and RFID based livestock programmes for tracking, theft prevention and vaccination records (Botswana, Senegal and Namibia).



Education	MDG 2: Universal Education	SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	i. Smart identity cards with biometric features for all public school students to improve service delivery (Nigeria); ii. biometric clocking device to improve teacher attendance in real-time (South Africa).
Environment & Conservation	MDG 7: Environment	SDG 12: Ensure sustainable consumption and production patterns. SDG 13: Take urgent action to combat climate change and its impacts. SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss	i. Radio-based cloud-connected devices to identify and track the presence of illegal fishermen (Timor-Leste); ii. air pollution sensors to monitor urban outdoor air pollution (Benin); acoustic sensors to monitor sea bird populations (global); iii. sensors and connectivity to protect game park perimeters and track animals (Africa); iv. connected unmanned aerial vehicles monitor national parks and connecting images from camera traps (UAE); v. acoustic sensors in tropical rainforests 'listening' for illegal logging (Indonesia).
Resiliency, Infrastructure and Energy		SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all. SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable.	i. Networked fire/smoke alarms in high-density urban slums/ informal settlements (Kenya, South Africa); ii. Connected buoys as part of the tsunami monitoring system (Indian Ocean); off-grid micro solar electricity systems for electricity for lower-income households (east Africa, India); iii. connected black carbon- and use sensors to monitor cook stoves (Sudan); sensor-connected matatus (mini-buses) tracking velocity, acceleration, and braking to curb dangerous operation of public transportation (Kenya).
Governance & Human Rights		SDG 10: Reduce inequality within and among countries. SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.	i. Retinal scans used for ATMs providing secure biometric cash assistance to displaced refugees (Jordan).



IOT in Nigeria

One of the most common forms of IoT adoption in Nigeria 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 [9]. 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 [10]. For the first time, INEC was able to track all vehicles carrying sensitive materials to locations real time from departure, en route and arrival. The new innovation was introduced at the Ekiti governorship election [11].

Another important applications of IoT in the country was the use of E-cards readers in the 2015 general elections. The technology was used to detect fake and cloned PVC within seconds and eliminated the possibility of a voter voting more than once for a candidate of his or her choice. The E-card reader thus curbed electoral robbery of massive thumb printing, which originated from the polling units and which has the potential of igniting crisis on election day and thereafter [12].

Another form of IoT deployment 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 and Mobile Authentication Service (MAS) 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. 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 [9].

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 [9].

The use of pre-paid meters in the electricity industry is another important application of IoT in the country. 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 [9].

The use of smart identity card integrated with biometrics to all public school students in Osun state is another useful application of IoT in Nigeria. The Osun Smart ID, an initiative of Chams Plc, is linked to a central database providing the state government with accurate data on the identity and number of students enrolled in its public schools [15]. The new biometric ID cards support the state government's initiative to deploy technology to boost the overall planning, allocation of resources and service delivery in the education field.

To create a safer motoring environment, The Federal Road Safety Commission in line with the resolutions reached with Standard Organisation of Nigeria (SON), Automotive Council of Nigeria, Transport Union Association and other stakeholders implemented and enforced the use of Speed Limiting devices in vehicles starting with commercial vehicles, nationwide. Speed Limiting Device operates through electronic sensors and the engine's computer. A series of sensors detect how fast the vehicle is going, then communicates that information to the engine's computer, which manages nearly all the engine's functions. Once the vehicle reach a pre-determined top speed, the computer steps in and restricts the flow of air and fuel to the engine and even the sparks that cause combustion. Either way, the vehicle will be unable to exceed the top speed as determined by the car's manufacturer [16].

Another form of IoT deployment in the country is the use of Flash Alert launched by the Nigerian Police Force to assist members of the public to report crimes anonymously, using videos, voice or text. Flash Alert is a technology that instantly alerts all the anti-robbery units in your state of residence as well as the Force HQ with the press of a button on your handset, or a simple flash from your phone in the event of a crisis or a crime.



Another technology deployed for improved security is Hawk Eye [17]. Hawk Eye App is developed by web Assets Nigeria Limited, a Lagos based tech firm, in partnership with US based tech firms BBGN&K, and Microsoft with the active collaboration of the NPF. The Hawk Eye Crime Reporting App is free and is available in English and Native languages which include: Hausa, Igbo, Yoruba and Pidgin. Citizens can download the Hawk Eye Crime Reporting app for free, select the crime type to be reported, capture image, video or call for help. The system uses GPS location services on the user's mobile phone to identify user's location for immediate police response [17].

Challenges to the Deployment of IoT In Nigeria

Despite all the exciting possibilities brought about by the IoT, significant challenges persist. According to [9], One of the main challenges to the deployment of IoT technology in Nigeria is the poor quality of service from network providers. While the deployment of 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. The International Data Corporation (IDC) believes that connectivity will be a major driver for the future adoption of the Internet of Things (IoT) in Nigeria [9].

Another limitation to the growth of IoT in Nigeria is poor power supply. The Nigerian Association of Energy Economists (NAEE) reviewed that, despite statistics indicating that 45% of the Nigeria's population is currently connected to the national grid, regular supply is still restricted to just about 25% of the population. According to NAEE, most of the people with access to electricity are found within urban areas of the country, leaving citizens in the rural areas with little or no access to electricity supply [13].

Further challenges may arise from human behaviour as a limiting factor, with reluctance to adopt new technology also a possible concern. People are often resistant and reluctant to modify their behaviour to fit with systems, and prefer that systems adapt to meet their needs [7].

Insufficient human capability is another limitation to the growth of IoT in Nigeria. There are often not enough technically literate people with IT skills in the country who are capable of implementing the use of sensors or other devices. Expertise will be needed in the areas of data mining, big data analytics, wireless sensor connectivity and cloud computing, among others. Furthermore, IoT systems also need regular maintenance, updates and function testing. If the system collapses, it has to be repaired quickly and rebooted [7, 9].

Low access to personal computers and the Internet is another challenge facing the development of IoT connections in Nigeria. The result of a research conducted by Oladimeji and Folayan [14] on ICT and Its Impact on National Development in Nigeria: An Overview shows that the majority of households in Nigeria continue to be excluded from the full range of communication services. Mobile telephones (63.9%) and TV (67.6%) have the greatest penetration at household level in Nigeria, and fixed telephony (0.4%) and access to computer (4.5%) are the least-accessed ICT tools, as shown in Table 2 below.

Table 2: Access to Information communication technology by Nigerians [14]

S/N	INDICATOR	PERCENTAGE
1	Individual access to Mobile telephones	63.9%
2	Individual ownership of mobile handsets	43.6%
3	Household Ownership of mobile telephones	59%
4	Access to fixed Telephony	0.4%
5	Access to computers	4.5%
6	Television access	67.6%
7	Radio access	41.2%
8	Ownership of radio	41.2%
9	Internet access	6.5%
10	Broadband penetration	6.1%

Conclusion

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. The Internet of Things consists of Smart Things. Smart Things are playing



an active role in our everyday life, and these applications are fabulous and countless. Whether we want it or not, we are part of this technological revolution and the most important thing is to learn how to use it properly and wisely. Therefore the efforts of all players in the world of Internet of Things such as device providers, operators, platform providers, systems integrators, application providers, governments and consumers should be united to ensure a secure and safety environment for communication and exchange of personal data.

To fully leverage the high potential of IoT applications in Nigeria to reach millions of people, and also to accelerate income growth and social development, it is recommended that:

- i. At the national level, policies should be put in place to support and facilitate the fast development of IoT, as well as eliminate the barriers and challenges.
- ii. Energy and basic ICT infrastructure in particular should be expanded, privacy improved and local know-how enhanced.
- iii. Efforts should be made to improve the quality of service offered by network providers in order to increase the speed of the Internet access.
- iv. There should be more training, awareness, exposure or workshops on the use of IoT devices.

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