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FEASIBILITY DESIGN OF A MOBILE PHONE FOR A FUTURE LOCAL PRODUCTION IN NIGERIA.

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ABSTRACT

The mobile phone system is one of the instrumental devices that has helped shaped our socio-economic ecosystem in many ways, and it has been an integral part of many societies all over the world due to its versatility. Nigeria currently is facing a great deal of economic hardship owing to successive political failures to balance the

Introduction

Over the last decade or more, Nigeria as perceived by her citizens have suffered severe economic decline as adjudged by exchange rate of the local currency against the US dollar. The Nigerian currency which is the Naira has been constantly weakened, a situation owed to the disproportion in the import and export activities; in other words, the export activities of

import-to-export ratio over the years thus affecting the nation's Gross Domestic Product (GDP) and Gross National Income (GNI). Domestic production of mobile phones has been identified as one of the structures if put in place that can help in a national economic revival in terms of a technological revolution that would contribute to the GDP, GNI, and general economic effect. In this paper, we examined the feasibility of the local production of the mobile device by embarking of a design prototype using a number of tools ranging from schematic CAD software, Human Machine Interface, and a number of electronic components coupled with a microcontroller board. Having the prototype tested to be working, the feasibility of embarking on domestic production shows a green light.

Keywords: Mobile phone, GSM, production, manufacturing.

Nigeria is far less compared to her import activities. In order to overturn this situation, the simple solution is to beef up export activities.

In order to achieve the aforementioned, the science and engineering disciplines have been challenged to rise to the occasion of exhibiting their expertise and skills and translating them into major and tangible turnaround of Nigeria economic woes. One of the areas the authors have considered in contributing to the economic overturn of Nigeria is the local production of mobile phones considering that it is one of the product with the largest market that are imported and have proven to be versatile across socio-economic spectrums. Having this feat achieved may not massively help to reduce the gap between the export and import activities but it will surely help to move a step closer to the goal alongside creating many opportunities that would come with it such as job opportunities.

Mobile phones are one of the technology that have transformed our modern day lives. The impact of mobile phones in Nigeria is

immeasurable ranging from live safety to cost savings, and many other socio-economic benefits that comes with it were focal in the authors decision to embark on seeing out the viability of the project.

To align to the ninth (9^{th}) goal of the Sustainable Development Goals (SDGs) (Osborn, Cutter, & Ullah, 2015), this paper therefore embarks on the design of a prototype of a mobile phone system that could serve as foundation for future mass production of the system in the country. This paper is organised as follows - firstly, we describe the evolution of the cellular mobile network from one generation to the other. Secondly, we present a literature review which highlights the importance of mobile phone and its spectrum of usage in the modern world, which further consolidates the authors decision to embark on this project. Thirdly, we showcase the materials required for the prototype and the design procedure itself. Fourthly, we perform a cost analysis for the prototype and made a projection for future cost for the production of the usable device. Finally, we conclude and offer recommendations for future work.

Evolution of Mobile Phone Technology

It is often said "everything that has a beginning must have an end". In the case of technology especially mobile phones, this is totally the opposite as we have never or can ever imagine the end of it. Mobile phone keeps coming up with new innovation and sophistication in functionalities. In the first generation of mobile phones, known as 1G, their only role is transmitting voice information from one location to the other and this was achieved through analogue transmission. The era of second generation called the 2G network ushered in new functionality in addition to voice calls which include text exchange in form of Short Messaging Service (SMS) and data transmission; this was aided owing to the digital communication in which the network generation was built upon. The 2G era experienced a semi-evolution in the name of 2.5G and 2.75G which saw the improvement in the speed of data packet

transmission through the introduction of Global Packet Radio Service (GPRS) for 2.5G and Enhanced Data Rate for GSM Evolution (EDGE) protocols for 2.75G (Arshad, Kashif, & Quershi, 2019). The 2G's GPRS and EDGE access technologies offers data rates in the regions of 150Kbps and 384Kbps (Yadav, 2017) respectively. In a bid to improve voice calls, throughput for data transmission, and Quality of Service (QoS), the third generation (3G) network was birth (Jaiswal, Kumar, Kumari, & Science, 2014). The 3G network offers data rate in the range of 384Kbps for pedestrian users, about 2Mbps for indoor users, and 144Kbps for mobile users (Alnaas, Laias, Alghol, & Akeel, 2018). Technology standards that typifies the 3G network includes Code Division Multiple Access – 2000 (CDMA-2000), Wideband Code Division Multiple Access (WCDMA), Universal Mobile Telecommunication System (UMTS), and Time Division Synchronous Code Division Multiple Access (TD-SCDMA) (Arshad et al., 2019). Similar to the 2G era, the 3G network semi-evolved to 3.5G and 3.75G with the latter referred to as High Speed Downlink Packet Access (HSDPA) and the latter referred to as High Speed Uplink Packet Access (HSUPA). The HSPDA simply improves the downlink data rate from 8Mbps to 10Mbps while the HSUPA improved the uplink transmission to a data rate of 5.8Mbps, thus closing down the delay gap between the uplink and the downlink (Arshad et al., 2019). To cater for the speed requirement of the modern day applications, a 4G era was sworn into action with a maximum speed bar of 100Mbps at a bandwidth of up to 40MHz especially during cell handover period. The key access technologies that consolidates the 4G networks includes Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (WiMAX), MC-CDMA, and Network-LMPS. One major shift in 4G from the preceding technologies is the adoption of IP based packet switching system across board rather than the mix of both circuit switch network and packet switch network of the preceding network generation. As year goes by, demand for very high speed, low latency and high capacity

connection by emerging applications such as Virtual Reality (VR), Augmented Reality (AR) spurred a radical movement into 5G network. 5G technology boast a data rate of at least 1Gbs (Pandya, 2015) and latency transmission of less than 10ms.

Overall, different generation of networks is accompanied with different design and specifications of mobile devices that operates under their radar. Basically as each generation comes by, more and newer functionalities, responsibilities and sophistication are associated with the mobile devices. For example, mobile devices in the 1G era are bulky and can only do voice transmission while the mobile phones that operates in the 2G era became smaller with new functionality added to it. In the 3G era, the mobile phones could transmit mid quality images and videos, and even live video transmission can be done by them. In the 4G, mobile phones can comfortably store and transmit HD videos as they are equipped with high grade antennas and high capacity storage. 5G phones comes with further high capacity storage and low latency sync capability with cloud resources where additional storage can be stored and retrieved as aided by edge or fog computing.

Although the long term aim of the authors is to be able to attain the required manpower and resources to produce modern sophisticated phones locally, our aim is currently focused on being able to successfully produce a feature phone and from there gradually and fully transition into building a more powerful, modern and sophisticated mobile phones. This is strategically thought of as we hope to gradually gain ground in the already competitive market whereby we hope to target low income earners and technically know-how deficient demography. Firstly, with no official data to back up the claim, we assume that at least 20% of Nigerians are not able to afford to buy smart phones and thus the feature phones productions can be targeted at these demographics. Secondly, we believe about 15% of Nigerians are technically deficient in operating smart phones and thus a simple operated phones would automatically

be their choice of use. Lastly, it is observed that most Nigerians acquire feature phones in addition to the smartphones they possess simply because it lasts longs in terms of power consumption and thus make them reachable for an extended period of time than the smart phones.

Literature Review

Mobile phones have had crucial role to play in the lives of people in different dimensions. In addition to the primary functions of making calls, as years passed by, the devices have offered more functionalities such as exchange of text information which are either in form of Short Messaging Service (SMS), electronic mails or Instant Messaging (IMs) such as in Whatsapp and the likes. There are many other crucial roles that mobile phones have played such as small record keeping, alarms/reminders, keeping tasks/work schedules, monitoring and keeping health records, and keeping up with sacred books such as the Holy Quran and the Holy Bible. Transition from less sophisticated feature phones into the development of smart mobile phones is believed to be influenced by efforts to achieve more functionality from one generation of cellular network to the other. On this basis, more and more features have been added to modern mobile smart devices to the point of almost becoming a powerful computing systems like laptops, desktops, or servers. Today, highly complex mobile phones are equipped with a number of specialised sensors such as light sensor, GPS, proximity sensors, light sensors, accelerometer, gyroscope, and so on (Khan, Xiang, Aalsalem, & Arshad, 2013). These peripheries have made them greatly versatile, thus being found useful in various applications and spheres of life.

Azubuike and Obiefuna (2014) established that GSM systems have aided employment creation for Nigerians which thus diffused crime rate. However, the authors believed the impact it has on the rural area is relatively low. One of the reason this could be is due to inability of the

rurual livers to afford the device; for this reason, we believe if local production is encouraged, a low cost can be attained such that the rural settlers can easily have access to it without barriers.

Chindo (2013) performed a time series analysis of the impact of GSM sub-telecommunication sector on economic growth in Nigeria and from their analysis, it was established that GSM has served as one of the major contributor to the nation's GDP. This raises a high hope that if the GSM devices that were imported could make a significant mark on the country's GDP, how much more when the devices are locally produced. It is projected that the country's GDP would shoot up by a factor of at least 1.5 if mobile end devices are locally manufactured.

In the early days of mobile phones in Nigeria, the device made a significant shift in the social spectrum of the people. For example, due to hard inaccessibility of the analogue fixed land phones operated by the defunct Nigeria Telecommunications Limited (NITEL), many Nigerian relatives were greatly out of touch with each other. In the advent of having to relay urgent information to a widely geographically separated relatives, they have to board a vehicle and transport themselves to the person's location in order to deliver the message. In fact, as popularly portrayed by Nollywood movies, there are a number of stress involved in locating the target subject's address especially if they reside in a big city. Thankfully, when mobile phones started penetrating the Nigerian populace, all the risk involved in physically transporting oneself from one place to another to convey a message to a given subject was eliminated, so is the stress involved, all of which can potentially result in one's health breakdown or even result in fatal or mild accident. Additionally, there is usually high financial cost attached to this kind of adventure. Thus Nigerians at the time mobile phones was ushered into their social system were utterly grateful and relieved of all the hassles they experience prior to the arrival of the technology.

When it comes to business, especially farmers, farmers through the use of mobile phones have in one way or the other made more revenue by cutting unnecessary expenses involved transporting their goods to a remote market usually situated in a city where they cannot predict the outcome of the sale. Previously, farmers go to the market on a blind faith to sell their produce; they might eventually not make any gain on the produce especially if they are perishable goods because buyers often play the mind games that they (buyer) can price their (the seller) market in any manner knowing they (the seller) will not want to return to their remote rural destination with the produce as they might eventually lose everything. Fortunately, with the advent of mobile phones, farmers often make bargain with potential buyers before setting out to deliver their produce to them. In situations where they do not have buyers, they can reach out to connection of friends until they get a buyer for their produce. The scenario painted here is further consolidated in the work of Bakare, Gold, and lsquo (2011). However, there still lies the problem of low penetration of the technology in rural areas, thus we hope our work will in long term address this problem.

In area of security, mobile phones have helped people to pre-empt critical security situations by alerting each other in case of danger. Most often, there are dangers that could have been averted if well aware ahead of time. Nigerians often rely on some form of reconnaissance means to anticipate bad situations. The advent of phones has helped people in a great deal not to consult these fetish/diabolic entities to be made alert of impeding dangers or unwanted situations. People now make use of mobile phones to alert their friends and loved ones of any unpleasant situations that may be happening. For example, parents call their children not to travel late into the town if there is any unrest, or even not to come at all, unlike prior to the widespread of the mobile phone technology where subjects would have entered in to crisis zone unaware of which they might not be lucky to come out of it. Also, public

transport drivers connect with each other to alert each other of traffic or road conditions so as to aid them to re-route their movement.

The introduction of Unstructured Supplementary Service Data (USSD) has further eliminate the need to acquire the technical know-how associated with operating smart phones thus this can be very helpful for technically deficient people which are commonly found in rural areas.

Mobile phones have found applications in device remote control through the use of SMS, before the widespread of the Internet of Things (IoT); one of such example is portrayed in the work of Das, Sanaullah, Sarower, Hassan, and IJECS (2009) a cell phone is used to remotely control appliances in homes and offices. In the same vein Bekiroglu and Daldal (2005) remotely controlled an ultrasonic motor with the aid of a GSM phone. Many other exploits of the mobile phones include the work of Raj, Tirupathi, Krishna, Sateesh, and Balachander (2016) where a multi-purpose GSM-based interactive embedded data acquisition system was designed to help for accident victims; the work of Gürüler (2015) where a GSM-based user-machine was designed to remotely interact with a refrigerator; and host of other applications. Indeed, the mobile devices have been versatile across sectors of life and its effect on life is immeasurable.

Methods and Materials

Following the literature studies presented above, a prototype design for the phone was experimented with to see the feasibility for future actual production. A GSM module, an Arduino Uno board, and a Nextion LCD touchscreen module were obtained. First, the Nextion LCD screen touch module was connected the Arduino controller board. Then, the SIM900 GSM module was connected to the Arduino controller board. Basically, the Arduino controller board performs the coordination function between the input-output interface provided by the Nextion LCD module and the SIM900A which communicates with subscriber's home network

of the SIM card present on it. The connection schematics can be seen in Fig. 1. A Human to Machine Interface (HMI) software called "Nextion Editor" was used to design the interface as shown in Fig. 2; the major part of the interface includes the phone number dial interface and the SMS sending and receiving interface. The outcome of the interface design at runtime is shown in Fig. 3. A small operating program was written on the Arduino to perform call dial, call receive, and Short Messaging Services (SMS) sending and receiving. The block diagram of the Nextion LCD interface, Arduino controller, and the SIM900A GSM module can be seen in Fig. 4. The program was successful in achieving the objectives for which it was written. The operating code utilises the AT commands provided by the SIM900A module to achieve these functions. For example, the ATD command was exploited to achieve call dial, and AT+CMGS and AT+CMGF were exploited to achieve SMS transactions.

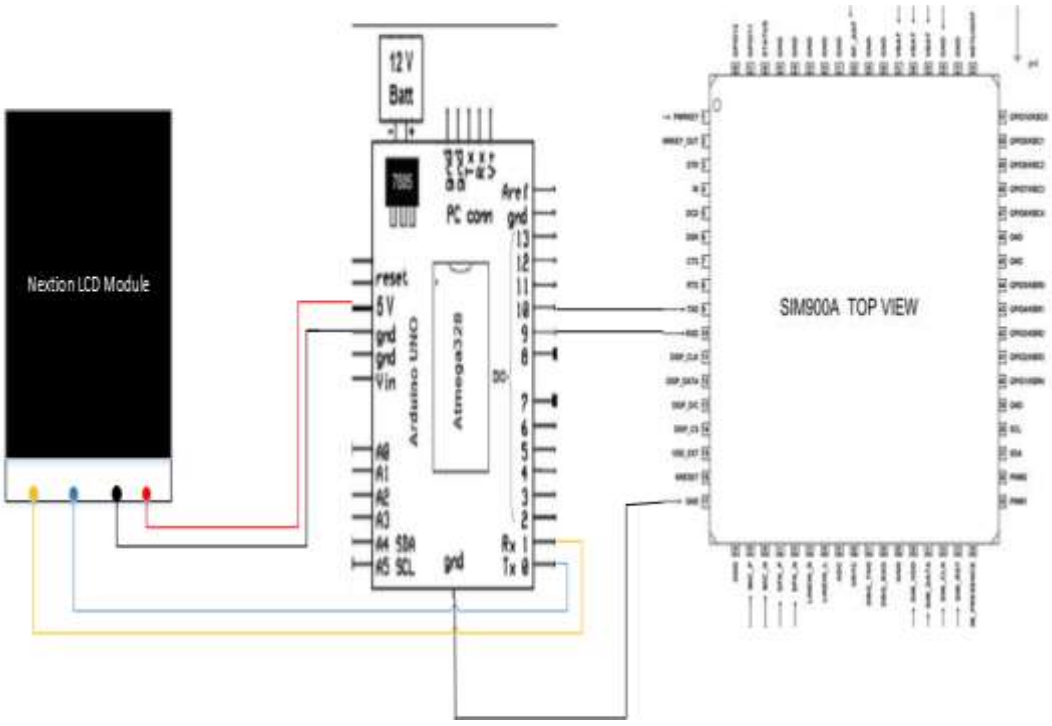

Fig. 1: Schematics of the developed prototype

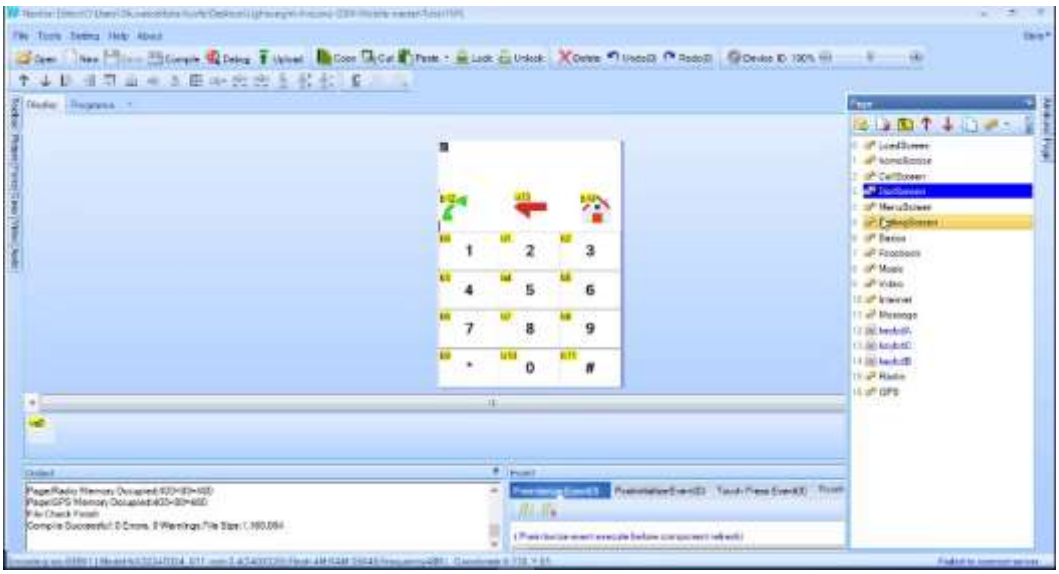

Fig. 2: Interface design using the Nextion Human Machine Interface (HMI)

(a) Phone boot interface at runtime

(b) Phone home screen interface at runtime

(c) Phone menu interface at runtime

(d) Dial screen interface at runtime

(d) Making phone call interface

(e) SMS sending interface

Fig. 3: Various phone interface design at runtime

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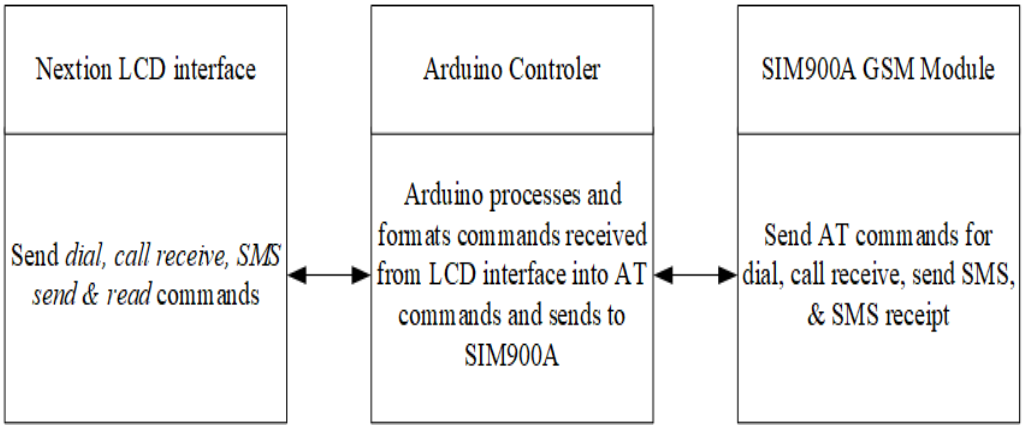

Fig. 4 : Block diagram of operation of input/output interface, controller, and the SIM900A GSM module

While the main function of a phone was implemented, many accompanying functions of phones such as time (alarm, stopwatch), contact storage, etc. were not implemented. This work as shown in Fig. 1 is simply done to examine the feasibility of the project, and not to implement the full functionalities that comes with most phones, on the small piece of hardware in use. It should be noted that many of these utility functions are more software oriented and so would be kept as a different task entirely from hardware. The main focus of this work is to implement software central to the operation of the designed phone hardware and its operation especially as regards signal and communication manipulation. This task however would require a great deal of technical know-how to implement through the various Digital Signal Processing (DSP) techniques. Thanks to the evolutionary advancement of System on Chip (SoC) production where all communication electronics are embedded into a single chip, the challenges associated to working with DSP techniques has been tremendously alleviated. One typical example of SoC is the MT6162DA by MediaTek. Also, the SIM900A chip shown in Fig. 1 is another typical example of SoC. The various features and periphery the MT6162D SoC (Dai, 2014) comprises of can be seen portrayed in Fig. 1.

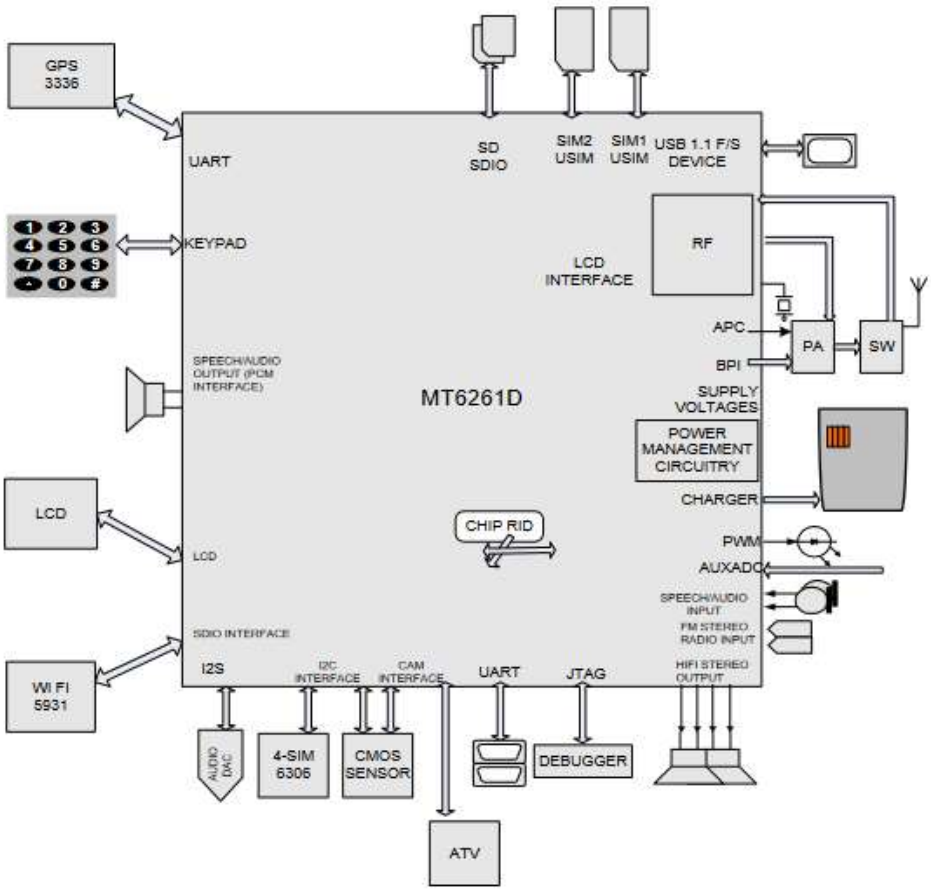

Fig. 1 - The MT6162 SoC Architecture (Dai, 2014)

Prototype cost analysis and long term projection

Here we present the cost required to complete a single prototype. Unfortunately, due to instability in the Naira denomination, the cost price would be presented in US dollars. The

Table 1 depicts the cost break down of the components involved in the prototype design.

Table 1 : Cost analysis for a single prototype of GSM device

S/N	Item	Cost ($)

1.	Arduino Uno controller board	17
2.	Nextion LCD screen	22
3.	SIM900A GSM module	23
	Total	62

From the

Table 1, the total cost required to complete a single prototype is $62 dollars which would be ₦25,730 in Naira at CBN's (CBN, 2022) value rate of ₦415 per dollar. Generally, cost of prototyping or singular production are usually higher compared to cost of actual mass production. However, the projected cost of single mobile device production is estimated to be in the region of ₦15,000. Fortunately, manufacturing company always gives a discount for increasing number of production thereby making cost per item to be quite low. For example, some Printed Circuit Board (PCB) manufacturing factory can offer a fixed discount of 5% for every ten (10) items produced while some can offer incremental discounts of 5% up till a certain threshold (say 20%) for every incremental interval; e.g. for every 10 items produce, a 5% discount can be offered and if it doubles to 20, the offered discounts can be doubled as well to 10%. Putting this into consideration, it is projected that a mass production could offer about ₦6,000 in the initial production while it can go as low as ₦3,000 in the long run. All these scenarios are of situations where production is outsourced oversea. If they are locally mass produced, then the production cost can be as low in the range of ₦1,500 and ₦2,000. However, the initial capita cost required to set up the PCB factory is huge and the Return on Investment (ROI) would be on a long term.

Conclusion and recommendation

In this report, what it takes to embark on the production of mobile phones domestically in Nigeria was examined. First, we presented the

evolution of the network under which mobile devices operates under, then we proceed to discuss the significance and impact the mobile devices have had on the Nigerian socio-economic terrain and what further benefits can be gain off from it if locally designed or produced in Nigeria. Next, a prototype design was made to test the feasibility of the production venture. In the advent of a prototype design at a small scale, this work has given a great deal of motivation to the feasibility of a full fledge production of the mobile phone, especially through local design but outsourced production, or with adequate funding from both private and public sector, a full cycle domestic production is a possibility.

Future work would consider the costs, logistics, machinery, resource materials, and other things to put in place in order to achieve a full cycle domestic production of the device.

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