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TECHNOLOGY CONVERGENCE AND THE PROMISE OF INTERNET OF THINGS: PROSPECTS FOR DEVELOPING ECONOMIES

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PREAMBLE

My recollection of Public Lectures I attended while at Obafemi Awolowo University (OAU), (formerly University of Ife). I managed to attend only a few of them either because of the renown of the lecturer or my level of interest in the topic.

One such lecture which I recalled very much was given by late Prof. Awojobi, distinguished professor of Mechanical Engineering at the University of Lagos.
His topic was, however, NOT on Mechanical Engineering. It was about the politics of Nigeria at the time.

Fortunately or unfortunately, my lecture today will NOT be about politics, even though I have my opinions but I am not an expert on the politics of Nigeria. So, I will keep my opinions to myself.

Nevetheless, I wish to remind everyone of voting age to remember to exercise your voting rights in the Nigerian 2015 elections in just a few short days.

In actual fact, much technology has been applied to try to perfect the process of choosing our leaders by democratic means based on the principle of one-man or woman, one vote.
Even if you don't like either candidate of the 2 major political parties (or of the remaining 12 minor parties), you still have to exercise your right to vote. Choose the candidate that, in your opinion, represents "…..the lesser of two evils…." Neither is actually "evil".

I have chosen a topic that I believe blends well with my expertise and tries to develop a narrative of technology and the impact it is having and will continue to have on all of us all over the world.

A brief history about my fascination with technology

Before I try to present my ideas on *"Technology Convergence and the Promise of Internet of Things* : *Prospects for Developing Economies*", I want to first give you my history as an engineer.

Electrical Engineering is a fascinating and interesting field of engineering. As a young boy, I had always been fascinated by technology and from an early age, always wanted to know the science and engineering underlying the amazing use of technology. For example, the AM/FM radio was a big deal when I was growing up and I once dismantled my father's old AM/FM radio to study how it works.

In secondary school, I studied science but my major subjects were (in order of interest) (i) advanced mathematics, (ii) mathematics, (iii) physics and (iv) chemistry .

I recall enjoying the physics experiments we did in our science lab and enjoying the rigor and certainty of solving math problems. Later, I started to ponder what I wanted to do as a career and become as a professional.

The US manned lunar landing on July 20, 1969 was a watershed event for me. It was transmitted live on television at about 11:30pm local time. I asked my dad to drive me to school (because we did not have a TV at home) so I could watch it live. I watched it live on a black and white television in our school library.

It was fascinating to me and since then, I had wanted to understand how such a system can be built to accomplish the hugely phenomenal task of landing a man on the surface of the moon and returning him to earth

safely. This monumental event was a major catalyst that launched a desire in me to study electrical engineering.

Another possible impetus for me to study electrical engineering was that my elder brother was also studying to be an electrical engineer.

According to Wikipedia (the internet based encyclopedia), *"Electrical Engineering is the field of engineering that generally deals with the study and application of electricity, electronics, and electromagnetism. This field first became an identifiable occupation in the latter half of the 19th century after commercialization of the electric telegraph, the telephone, and electric power distribution and use. Subsequently, broadcasting and recording media made electronics part of daily life. The invention of the transistor and, subsequently, the integrated circuit brought down the cost of electronics to the point where they can be used in almost any household object……."*

I believe electrical engineering is behind the major technological breakthroughs of the last two centuries. Electrical engineers have brought us a wide range of technology, new design challenges such as Mobile cellular phones, Satellite and wireless communications, high-speed railways, computed imaging for health, digital photography, electric cars, self-driving cars, alternative energy sources (solar, wind, hydro, nuclear, etc.), robotics, cyber-physical control systems, distributed sensor networks, medical devices, personal assistive devices, etc. and the list goes on.

A BRIEF HISTORY OF TECHNOLOGY

In history, there are many changes which historians sooner or later call a "revolution". Actually, it can be better succinctly stated as a confluence of events or what I prefer to call convergence of technological developments.

We have also witnessed the following recent revolutions: There was:

the industrial revolution; then

the information technology (IT) or computer revolution; then
the internet revolution.

Now we are poised for the next revolution: The Internet of Things (IoT) or The Internet of Everything (IoE) which we will discuss later.

The Industrial Revolution

I begin a narrative of a brief history of technology with the Industrial Revolution.

The Industrial Revolution (about 1760 to about 1870) marked the transition from the middle and dark ages to new manufacturing processes. Machine tools were developed such as the printing press (with attendant impact on education and literacy). This included moving from hand production methods to machines.

In addition, we had improved efficiency of water power and the increasing use of steam power. The steam engine, locomotive engine and even automobile engine, etc. came as a result of the Industrial Revolution. We are still enjoying some of the benefits of the Industrial Revolution today. The lasting benefits include:

standard of living was raised;
income levels rose;
new economies based on new products began to materialize.

The Industrial Revolution began an era of per-capita economic growth in capitalist economies around the world.

Imagine that about 120 years ago, there were no airplanes and no airports because flying was not yet mainstream. But today, there are many international, national and local airports all over the world.

Similarly, about 125 years ago, there were no cars and therefore not many highways and bridges. These inventions came around the beginning of the last century.

Today, there are hundreds of thousands possibly millions of kilometers of highways and bridges all over the world. Of course, we will not discount the millions of cars and other forms of transportation. Civil engineers who design and build airports, bridges and highways have been enjoying continuous employment, thanks to the new technologies of airplanes, cars and trucks. Similarly, the mechanical engineers, petroleum engineers, electrical engineers and others have found gainful employment, thanks to theIndustrial Revolution and its aftermaths.

The Computer revolution

Then came the computer revolution. Computing dates way back to the times of Abacus, slide rule, analog computers, etc. More recently, there was the mainframe digital computers housed in large air-conditioned rooms with only card-reader access. Examples are the IBM 360, PDP-11, etc. The IBM System/360 was announced by IBM in 1964 and delivered between 1965 and 1978.

What has happened since the early 1980's is the personalization of the computer as something one "owns" and uses at home. IBM introduced their very successful personal computer (PC) in the early 1980's. In 1982, "The Computer" was named Machine of the Year by *Time* Magazine. A small company known as Microsoft co-founded by Bill Gates (a Harvard drop-out) provided the Operating system for that first IBM PC. Since then, Microsoft has grown to become one of the largest software companies in the world. The whole business of software development has become a mainstream profession due to the demand for such skills. Meanwhile, the Harvard drop-out has become the richest man on the planet.

The Personal Computer (PC) Revolution lasted from about 1980-2000. Today, there are many devices such as mobile phones, tablets, etc. that combine many functionalities.

The Internet Revolution

The original Internet was an experimental network known as the ARPANet, designed by the US Department of Defense to connect four mainframe computers in several parts of the US in order to communicate and share computing resources effectively.

The ARPANET was the first wide area ***packet switching*** network. Packet switching is the method of transmitting information in packets from one computer to the other until it finally arrives at the destination. This concept is different from the prevailing method of establishing a dedicated transmission channel between sender and receiver. This was knows as ***circuit-switching***.
The first message on the ARPANet was sent and received on August 30, 1969.

There are many pros and cons of both methods, which we will discuss later.

Since the ARPANet was introduced in 1969, the growth of the Internet has been phenomenal, fueled by advances in computer hardware and software. A new field of computing known as Computer Networking was born. The advances in hardware have been following a popular law known as ***Moore's law***. Named after one of the founders of Intel, Gordon Moore, the law was an observation (stated in 1965) that the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented. Moore predicted that this trend would continue for the foreseeable future.

The ARPANET network has evolved into the ***Internet*** of today, connecting billions of computers worldwide. Today, one will not be surprised to know how many computing devices are connected to the Internet.

THE INTERNET

Now, we will discuss a few of the engineering ideas and principles that make the internet work.

The Internet is a connection of computers all around the world. It is designed as a network of networks.

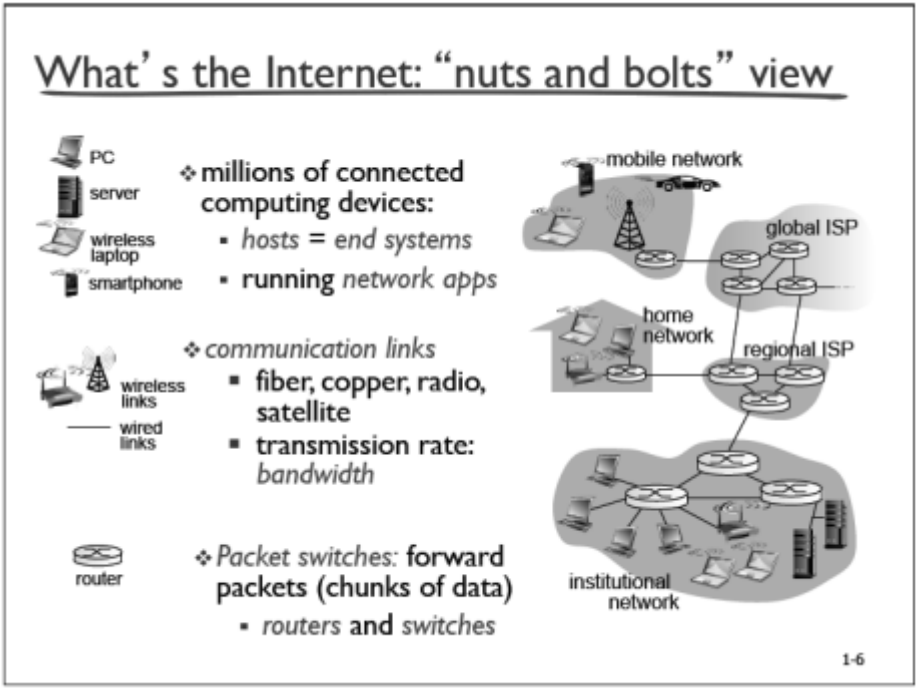


Figure 1 : The Internet "Nuts and Bolts" View

We have two views of the Internet: the nuts and bolts view and the service view.

See Figures 1 and 2. Here, the nuts and bolts view shows millions of connected ***computing devices*** (known as hosts or end systems) running network application programmes (***network apps***) and connected by ***communication links*** (e.g. optical fibre, copper wires, radio, satellite, etc.). These links have a transmission rate known as ***bandwidth***. The communication of information between these hosts is accomplished by forwarding chunks of data known as ***packets*** through ***routers*** and ***switches***. The method known as packet switching.

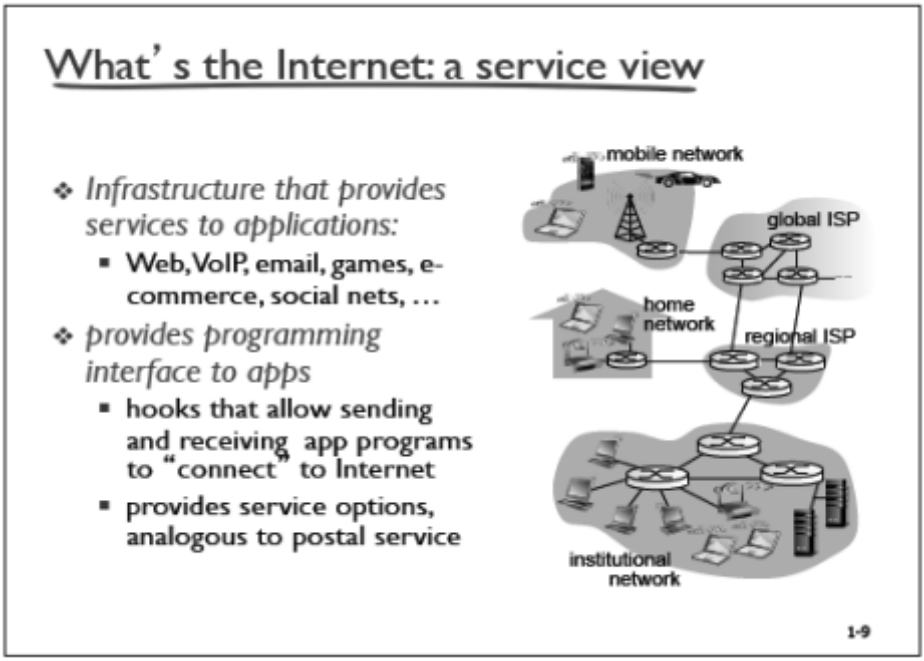


Figure 2 : The Internet service view

In the service view of the internet, the whole network is seen as an infrastructure that provides service to applications. Such applications

include Email, Voice-over-IP, World Wide Web, Social networks, Games, E-commerce, etc.

It also provides programming interface to the apps. These are hooks that allow sending and receiving app programs to "connect" to the internet. It also provides service options analogous to the postal service.

How does the Internet work?

The computing devices connected to the internet communicate by means of ***protocols***. The most popular of these protocols is the Transmission Control Protocol and the Internet Protocol known as TCP/IP.

Also each device connected to the internet has an ***address***. The ***Uniform Resource Locator (URL)*** is used to specify addresses on the World Wide Web. It is the fundamental network identification for any resource connected to the web (e.g., hypertext pages, images, and sound files). ***URLs*** have the following format: ***protocol://hostname/other_information***.

For example the URL address for the Covenant University Network is http://www.covenantuniversity.edu.ng

One bit is a binary piece of information (0 or 1) (TRUE or FALSE). *Bit* = *Bi*nary digi*t*.
One ***byte*** is defined as 8 bits of information

If you have an address of 2 bits, you can address 2^2 = 4 different locations
If you have an address of 3 bits, you can address 2^3 = 8 different locations

If you have an address of 4 bits, you can address 2^4 = 16 different locations
If you have an address of 5 bits, you can address 2^5 = 32 different locations

If you have an address of 32 bits, you can address 2^32 = 4.3 x 10^9 different locations

The IPv4 is a 32-bit address space capable of 2^32 = 4,294,967,296 unique IP addresses.
The maximum number of devices that can be connected to the current internet using IPv4 is just more than 4 billion.

Currently, there are two types of Internet Protocol (IP) addresses in active use: IP version 4 (IPv4) and IP version 6 (IPv6). IPv4 was initially deployed on 1 January 1983 and is still the most commonly used version. IPv4 addresses are 32-bit numbers often expressed as 4 octets in "dotted decimal" notation (for example, 192.0.2.53).

So, when youenter www.covenantunivesity.edu.ng, that URL address is actually mapped to a numeric address known as an IPv4 address. Covenant University IPv4 (Internet Protocol version 4) address is **71.6.221.71**.

Now, if you have a smart phone (mobile phone), you have the ability to have your own mobile IPv4 addresses. This is very good news…..it means you are connected to the whole world……..to billions of computing devices all the time through the Internet.

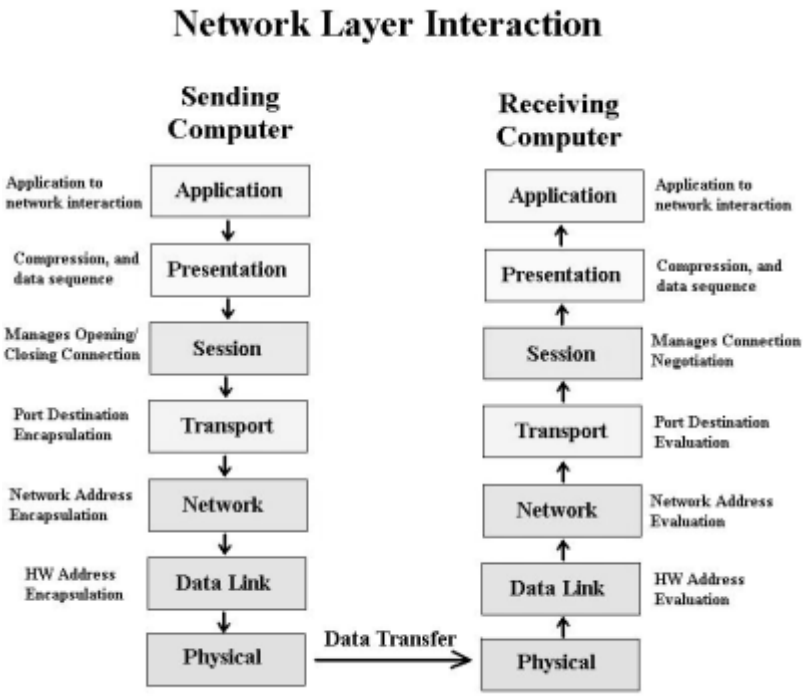


Figure 3 : Network Layer Interaction in the ISO OSI Model

What is ISO OSI Model?

The devices connected to the Internet are designed to communicate through a layered means of communicating. There are seven layers for each host computer. See Figure 3. The layers are:

Physical Layer (Layer 1)
Data Link Layer (Layer 2)
Network Layer (Layer 3)

Transport Layer (Layer 4)
Session Layer (Layer 5)
Presentation Layer (Layer 6)
Application Layer (Layer 7)

These 7 layers were defined by the International Standards Organization (ISO) and called the ***Open Systems Interconnection (OSI)*** Model.

What is TCP/IP Protocol?

TCP/IP is the protocol that has run the Internet for more than 30 years. TCP/IP is actually two protocols that operate at different layers of the OSI Model. TCP stands for Transmission Control Protocol. It operates at Layer 4, the Transport Layer. IP stands for Internet Protocol. It operates at Layer 3, the Internet Layer. TCP/IP is also a large suite of network related protocols that include TCP, IP, UDP, ARP, etc.

TCP and IP work together to provide reliable data transmissions. TCP handles communication problems that IP does not handle. TCP constantly monitors conditions on the Internet and automatically adapts. Therefore, TCP makes reliable communications possible even though the Internet experiences temporary congestion.

The original paper first describing TCP/IP protocol was published in 1974 and titled, *A Protocol for Packet Network Interconnection*, by Dr. Vint Cerf and Dr. Robert Kahn. It was presented about five years after the ARPANET was created.

The TCP/IP protocol was adopted on January 1, 1983 as a standard communication protocol for all connected hosts and the ARPANET thus became the Internet.

The basic TCP/IP technology has accommodated growth and changes

that the original designers did not imagine. For example, the original ARPANET had four computers. Now, the Internet has billions of computers connected. Thanks to hardware improvements due to Moore's Law, computers now operate over 2,000 to 3,000 times faster than the computers that existed when TCP/IP was first built. Even so, the TCP/IP protocol has not changed and is still the preferred method used on the internet.

The TCP/IP protocol is specified on standards documents known as RFCs (Request for Comments). These RFCs are publicly available from the Internet Engineering Task Force (IETF). The documents specify the exact way to send IP packets or datagrams on a given type of network, computers and routers from multiple vendors, which always have to agree on the details.

The TCP/IP protocol is mapped to the seven layers of the OSI modelas shown in Figure 4.

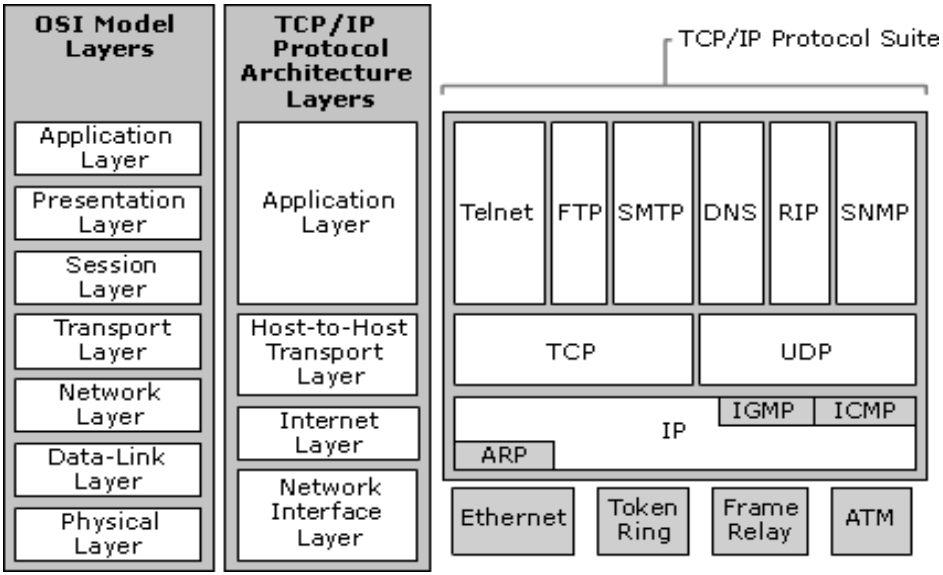


Figure 4 : The TCP/IP protocol within the ISO OSI Model

How the Internet works…… How does email work?

If you have ever wondered how the email you just sent gets to the recipient, the diagram in Figure 5 illustrates how in three steps.

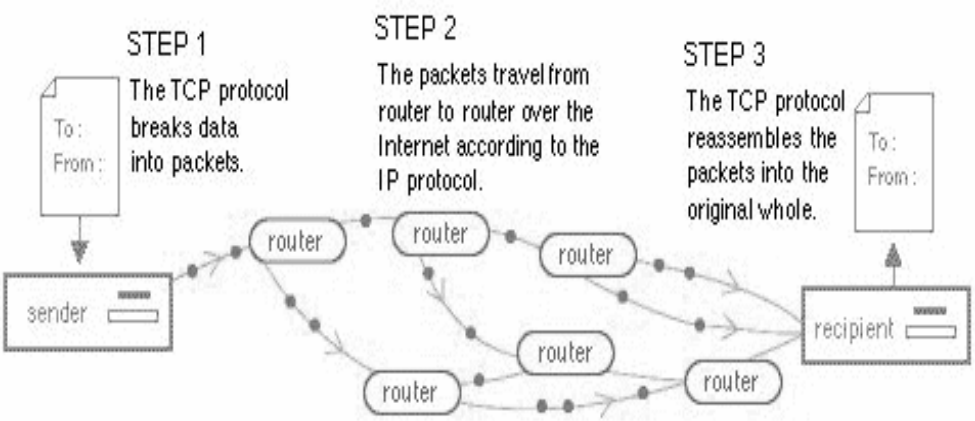


Figure 5 : How data travels over the Internet

One of the other governing bodies of the Internet is The Internet Assigned Numbers Authority (IANA), which is responsible for the global coordination of the DNS Root, IP addressing, and other Internet protocol resources.

Impact of the Internet

It is easy to see the impact of the Internet almost everywhere. For example, without an Internet, there would be no World Wide Web, and there would certainly be no Facebook, Google, LinkedIn, eBay, AMAZON.com, YouTube.com, CNN.com, covenantuniversity.edu.ng, etc.

The Internet exists today because of a convergence of advances in communications, computing, hardware and technical software made during the late 1970s and early 1980s.

We list a few of the impact items of the Internet below:

- Impact of the Internet is pervasive
    - Shopping, Banking, Education, Transportation, Health care, Entertainment, Television, Film/Movie industry, etc.
- US companies: eBay, Amazon, Facebook, Google, Twitter, Skype, etc. Many of these US companies are individually worth billions of dollars and have capital more than most African countries economies.
    - Almost all of these companies did not exist 20 years ago but they are now very successful and are an indispensable part of our lives. They are also responsible for the dislocation of previous industries.
- Nigerian companies: **MTN, Airtel, Glo, Etisalat, Jumia, Konga, MainOne, etc.**
    - These companies are very profitable Nigerian ventures…
- Social Networks phenomena: Facebook, Skype, FaceTime, Twitter, LinkedIn, etc. Imagine Facebook has over one billion subscribers.

- Potential Impact on Nigerian Elections: Biometric authentication of voters, real-time transmission of election results using the internet and so on.

Dislocation of industries due to the new technologies

Telephony service in Nigeria used to be accessible to only a small fragment of the population. I recall the days when there was a 5-year waiting period to get a landline phone from the old P&T.

Today, you can get a mobile wireless phone for a small amount of money from any of the major mobile wireless carriers MTN, Glo, Airtel, Etisalat, etc. in just a few minutes. There is virtually no demand for fixed telephone landlines from P.&T. anymore.

Similarly, there are very few pay phones left. Hotels used to realize a 10-20% of their revenues from hotel phone charges. Now, they have to look for other revenue sources e.g. charging customers for Internet use. Mobile and Voice over IP Phone have replaced traditional phones.

In addition, cell phones and tablets (e.g. iPads) with all the additional functionalities are everywhere.

Many people have become addicts of Social networks like Facebook, Twitter, FaceTime, Skype, etc. They don't take respite from the devices. They are always online and sending and receiving messages. This is a very interesting social phenomenon.

There are many other examples of dislocation of industries. Here are a few:

The Guttenberg printing press is currently being replaced by tablets for reading books, newspapers, just about anything that was previously printed on paper.

The printing of Encyclopedias is all but a bad business now. Thanks to Wikipedia, the dynamic online constantly-updated encyclopedia, which I might add, is a free resource.

Impact in law: Digital Rights Management (DRM) issues
Old business model: You buy a book and become the "owner" of the book event though you don't owe the copyright. You can lend the book to a friend or sell it.
New business model: You "rent" or "lease" a book for a length of time and read it.
Meanwhile new version or editions of the books can become available and you may need to upgrade to the new version. The rights owners are able to continue to exercise control over the access to the content of a work.

This has led to some new paradigms in education and textbooks.
Should I buy a book or just lease a book for a one-semester course?

Another Impact in education: An iPad for every child in elementary (primary) schools in the US. This is gaining in popularity with many school districts in the US.

Another is in content (music, video, etc.) copyright laws. The Internet has so much free content that we assume we have copyright access e.g. Are Internet posts (e.g. YouTube videos) protected by copyright laws?

The impact on Information retrieval is huge. Can Google digitize the whole information available in the human race? They're well on their way... Google's business goal is to do just that.

They want to manage the world's information and make it available at your fingertips.

Other examples of business disruption:
There is little or no more income for hotels from selling telephone service to customers. All the customers now have cell phones. Banking (ATMs, etc.), Shopping online, etc. are some of the other dislocation impact areas.

The "Uber" phenomenon. A company called "Uber" has changed the way taxis operate in many parts of the world. Uber is a web-based service to obtain taxi rides operated by the private drivers using their own cars to make extra money.

"Airbnb" is another company that helps you rent your apartment/house and make you money to compete with hotels.

Many jobs (e.g. Toll takers on highways) have been replaced by machines and the list goes on.

What is responsible for the growth in the Internet and for the future of IoT?

The following are responsible for this growth in internet use:

The availability of smartphones with Internet connectivity

The cost of WiFi bandwidth (Internet connectivity) has gone down 40 X over the last 10 years on average

The cost of computing resources has gone down 60 X over the last 10 years on average

The cost of sensors has gone down dramatically over the last 10 years (From $1.30 to $0.60) on average

The scalability of IPv6. It can address 3.4 x 10^38 unique IP addresses.

The so-called "digital divide" is no longer in the US. I also hope the digital divide will be a thing of the past in Nigeria and other developing economies. Everyone should have a computer……..This was one of the philanthropic goals of Bill and Melinda Gates' in South Africa as he explained during his commencement speech at Stanford in June 2014.

In addition,

I predict that Internet access will be FREE and ubiquitous by the year 2020.

Internet Access will become as free and abundant as the air we breathe.

This is already happening in some major US airports and in some US cities. For example, the city of Mountain View, California (headquarters of Google) enjoys free public internet service, thanks to Google.

TECHNOLOGY CONVERGENCE: WHAT IS IT?

Technological convergence is the process by which existing technologies merge into new forms that bring together different types of media and applications. New devices and technology usually handle one medium or accomplish some basic tasks. Through technological convergence, devices can interact with a wider array of media types. For example, a new type of media storage often requires new players that only play that format. As the technology advances, however, new models might include additional features like the ability to interface with more devices or play with other types of media.

Different forms of communication media previously used their own technologies. Voice conversations used a telephone, video communication briefly used high-end video phones, and e-mail required a computer. Technological convergence has resulted in computers and handheld devices like mobile smartphones and tablets that can provide all of this functionality with a single electronic piece of equipment.

The Internet is perhaps the most widespread example of technological convergence. Virtually all entertainment technologies, from radio and television to books and games, can be viewed and played online. Many computers with Internet access offer greater functionality than primary devices like media players or e-Readers for digital books. All of these different types of media have become digitized and made more readily available than ever before.

Smartphones are an example of technological convergence, as they provide the functions of different devices, like telephones and cameras, in one product.

As tablet computers can be used to play video games, send e-mails, and download music, they are considered an excellent example of convergence technology.

Telecommunications convergence, network convergence or simply convergence are broad terms used to describe emerging telecommunications technologies and network architecture used to migrate multiple communications services into a single network. Specifically this involves the converging of previously distinct media such as telephony and data communications into common interfaces on single devices, such as *most smart phones can make phone calls and search the web*.

The rise of digital communication in the late 20th century has made it possible for media organizations (or individuals) to deliver text, audio,

and video material over the same wired, wireless, or fiber-optic connections. At the same time, it inspired some media organizations to explore multimedia delivery of information.

Today, we are surrounded by a multi-level convergent media world where all modes of communication and information are continually reforming to adapt to the enduring demands of technologies, **"changing the way we create, consume, learn and interact with each other"**.

Convergence, in this instance, is defined as the interlinking of computing and other information technologies, media content, and communication networks that has arisen as the result of the evolution and popularization of the Internet as well as the activities, products and services that have emerged in the digital media space.

This is simply the tip of the iceberg, as all facets of institutional activity and social life such as business, government, art, journalism, health, and education are increasingly being carried out in these digital media spaces across a growing network of information and communication technology devices.

Convergent services, such as VoIP, IPTV, Mobile TV, Smart TV and others, tend to replace the older technologies and thus can disrupt markets. IP-based convergence is inevitable and will result in new services and new demand in the market.

When the old technology converges into the public-owned common, IP based services become access-independent or less dependent. The old service is access-dependent.

THE BENEFITS OF TECHNOLOGY CONVERGENCE

There are many benefits to technology convergence. However, there are also disruptions to existing products and services. For example, ***Communications*** and ***Computing*** have converged, giving us

tremendous benefits such as mobile phones with many uses e.g Apple's iPhones, iPads (combine Wireless Communications, Computing, Digital Camera, Software Apps,etc.) Internet connectivity (Computing and Networking) etc. to save us time and offer many benefits.

These technologies have revolutionized our lives.

Example of Convergence in Telephony : PSTN to VoIP

A very good example of convergence is the convergence of telephony.

Previously, the Public Switched Telephone Network (PSTN) was built based on circuit-switching. Circuit-Switching establishes a wired connection between the sender and receiver of the telephone conversation. The connection is maintained throughout the validity of the phone call. This may not be the best use of bandwidth.

The alternative is the packet-switching methods of VoIP. This is a best effort (not guaranteed) attempt at transmission. Recall that the data is broken down into packets and transmitted over several connections (known as routers).

The PSTN, originally designed as an analog network, is being gradually converted to an all-digital network. In most developed countries, both old networks such as PSTN and new networks like the Internet and other communications networks exist side-by-side.

Here is a brief description of what happens when you place a call using the old PSTN:

The speech signal is converted from analog to digital, (see Figure 6) then transmitted over either the PSTN or any of the new networks. The PSTN uses circuit-switching while the new networks use packet-switching.

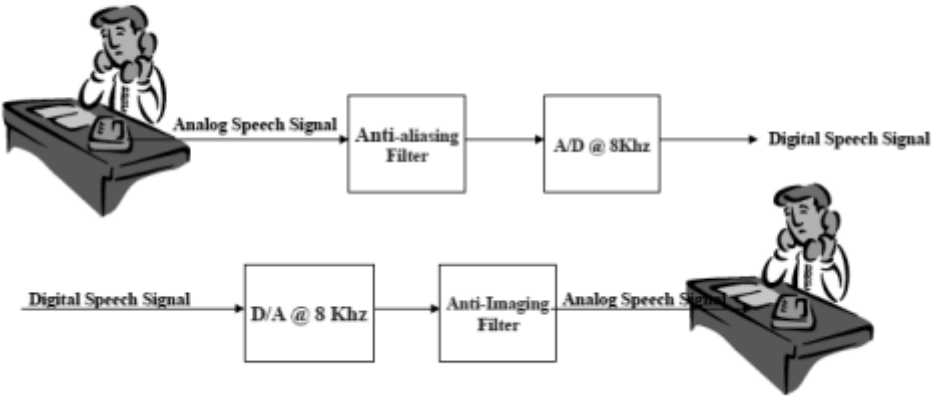


Figure6: Analog to Digital conversion of speech as seen in The Public Switched Telephone Network (PSTN)

Brief Explanation of DSP

One of the enablers of this convergence is the area of Digital Signal Processing (DSP). DSP has changed the way electrical engineers do business in the last 40 years and is continuing to do so.

Digital Signal Processing (DSP) is an enabling technology for Technology Convergence. Once a signal is converted from analog to digital, it is just bits and can be treated as any other bit of information. That is why the same network can be used for email, text, speech, video, audio, ***election returns***, etc.
When it comes to digital signals, *a signal is a signal is a signal is a signal*……regardless of source. For example, we can digitize a signal (e.g. speech) and store the information in the signal as a string of 0's and 1's (bits).

Brief Explanation of VoIP.

Voice over IP (VoIP) is the method of transmitting phone messages through the internet. The Internet was not designed for this so there are challenges. Many of those challenges have been overcome by recent research results. This has enabled VoIP services such Skype, GoogleTalk, etc. to work almost flawlessly.

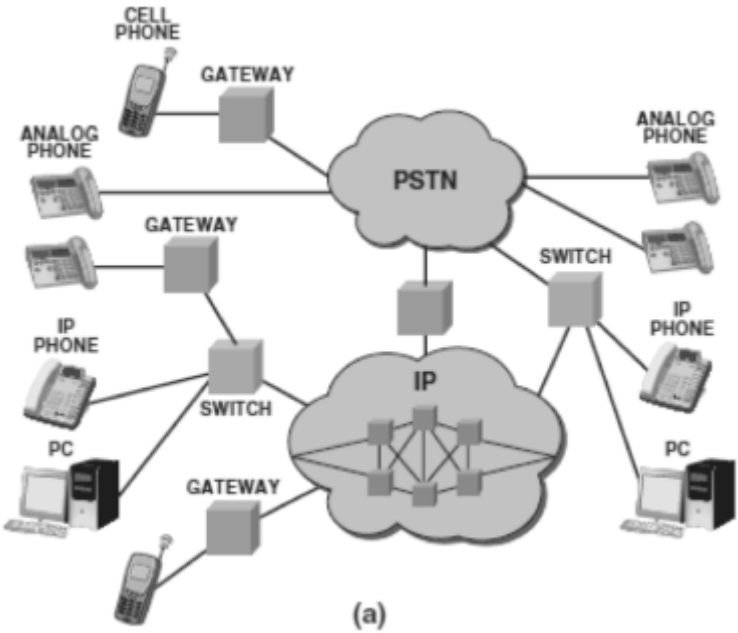


Figure 7: Transition from the PSTN to an all IP Network (Voice over IP)

To build new telephone networks in developing countries, you don't need to lay copper cable from the Local Telephone Office to every home anymore. Now we have Wireless Communications and other options such as the Internet to connect us.

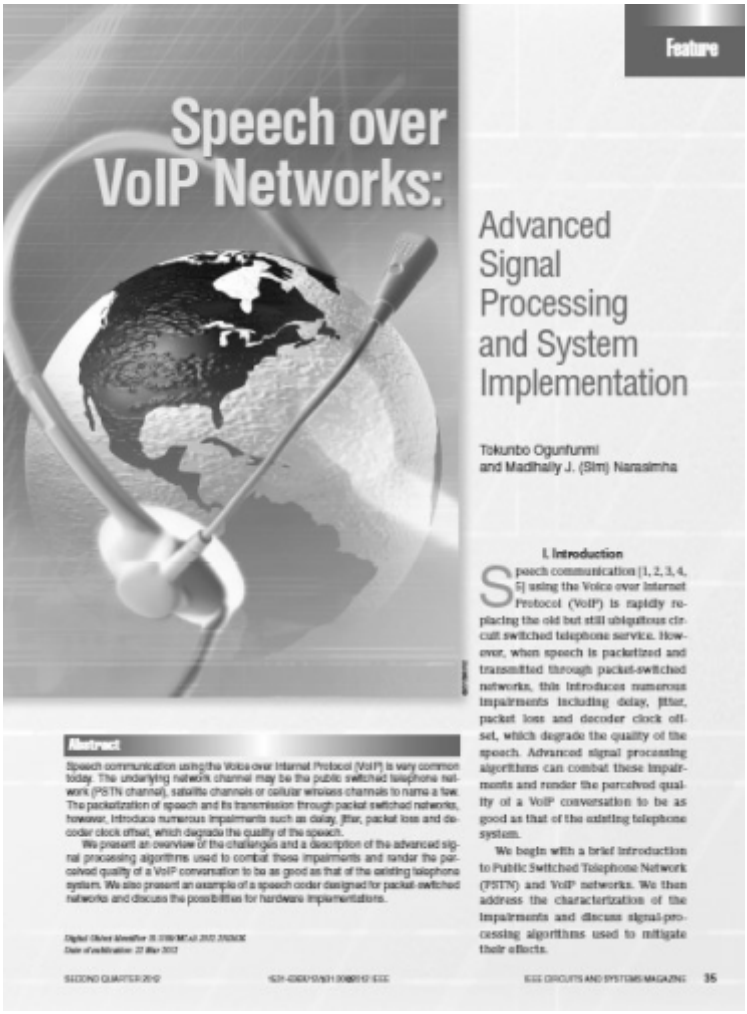
This essentially leapfrogged the many years of development stages other developed countries had to go through before the new era of wireless telephony. Also, the method of transmission has changed from circuit-switching with its limitations to packet-switching (it has its own limitations).

In many countries, the transition from PSTN to VoIP networks is already underway. According to the US Federal Communications Commission (FCC) document published about 2007.

> "*VoIP subscribers will surpass PSTN in 2013. PSTN is expected to decline at 9 % annually while VoIP grows at 27%.*"

This has already happened.
In addition, no one just planning a telephone network will use a PSTN system at the time. Many new telephone subscribers only have VoIP phones in their homes now. Examples in the US are myriad of VoIP offerings such as Skype, GoogleTalk, Magicjack, Vonage, Ooma, etc.

Challenge of VoIP
A major challenge of VoIP is the lack of guarantee for reasonable speech quality because of the possibility of packet loss. Thus we require High level of Robustness to Packet Loss.


Feature

Speech over VoIP Networks:

Advanced Signal Processing and System Implementation

Tokunbo Ogunfunmi
and Madihally J. (Sim) Narasimha

I. Introduction

Speech communication [1, 2, 3, 4, 5] using the Voice over Internet Protocol (VoIP) is rapidly replacing the old but still ubiquitous circuit switched telephone service. However, when speech is packetized and transmitted through packet-switched networks, this introduces numerous impairments including delay, jitter, packet loss and decoder clock offset, which degrade the quality of the speech. Advanced signal processing algorithms can combat these impairments and render the perceived quality of a VoIP conversation to be as good as that of the existing telephone system.

We begin with a brief introduction to Public Switched Telephone Network (PSTN) and VoIP networks. We then address the characterization of the impairments and discuss signal-processing algorithms used to mitigate their effects.

Abstract

Speech communication using the Voice over Internet Protocol (VoIP) is very common today. The underlying network channel may be the public switched telephone network (PSTN channel), satellite channels or cellular wireless channels to name a few. The packetization of speech and its transmission through packet switched networks, however, introduce numerous impairments such as delay, jitter, packet loss and decoder clock offset, which degrade the quality of the speech.

We present an overview of the challenges and a description of the advanced signal processing algorithms used to combat these impairments and render the perceived quality of a VoIP conversation to be as good as that of the existing telephone system. We also present an example of a speech coder designed for packet-switched networks and discuss the possibilities for hardware implementations.

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Figure 8: Challenge of VoIP: Inherently less reliable communication because of the possibility of packet loss. Some of the methods to combat this and other impairments are discussed here

A recent article in the IEEE Circuits and Systems magazine (Figure 8) details possible solutions to the challenges of sending speech over Internet-type networks. The paper by T. Ogunfunmi and M.J. Narasimha is titled “Speech

over VoIP Networks: *Advanced Signal Processing and System Implementations"*.

Where are Nigeria and other developing countries in terms of use of the internet?

The world map in the Figure 9 is telling. It shows the concentration of internet users all over the world in 2012.

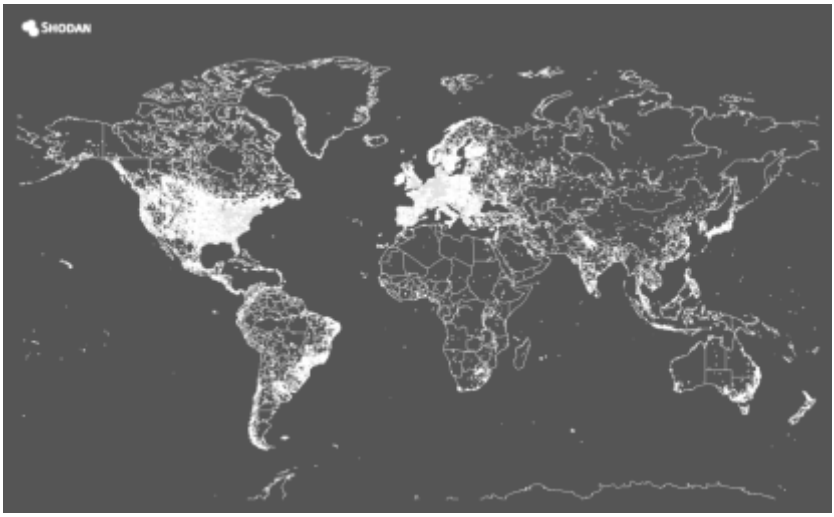

Figure 9: World map of 24-hour relative average utilization of IPv4 addresses observed using ICMP ping equests as part of the Internet Census of 2012 (Carna Botnet), June - October 2012. Key: from red (high), to yellow, green (average), light blue, and dark blue (low).

The map shows the location of all the devices connected to the Internet in the world. The redder the area, the more devices there are. In this map, you can see the correlation between numbers of Internet users and level of development.

As you can see from the map, the US and Europe have very high levels of internet connectivity, with the exception of the less-populated areas of the

western US. ***Africa is mostly an internet blackout***, and Asia has much less internet connectivity than Europe and the US despite having very dense population centers in some areas.

Try to find Nigeria on the map. You can get an idea of the number of users relative to other countries in the world. Also, the website http://www.internetlivestats.com/internet-users/#trend gives in real-time the number of users on the internet at any time.

THE ECONOMIC DEVELOPMENT IS TIED TO TECHNOLOGY

The data in the tables in Figure 10 shows in detail the list of countries by number of Internet users.

List of countries by number of Internet users

From Wikipedia, the free encyclopedia

This is a sortable **list of countries by number of Internet users** as of 2012. Internet users are persons using the Internet in the last 12 months from any device, including mobile phones. Penetration is the percentage of a country's population that are Internet users. Estimates are derived from either household surveys or from Internet subscription data.[1]

Non-country and disputed areas are shown in *italics*. All United Nations member states are included, except South Sudan. Taiwan is listed as a sovereign country.

Country or area	Internet users[2]	Rank	Penetration[3]	Rank
China	641,601,070[4]	1	46.04%	91
United States	279,834,232[5]	2	85.75%	28
India	243,598,922[6]	3	19.19%	164
Brazil	109,773,650	4	54.02%	86
Japan	109,252,912	5	86.03%	33
Russia	84,437,739	6	59.27%	81
Germany	68,296,919	7	84.0%	22
Nigeria	55,930,391	8	32.9%	128
United Kingdom	54,861,245	9	87.0%	14
France	54,473,474	10	83.0%	24
Mexico	44,173,551	11	38.4%	114
South Korea	49,512,026[7]	12	91.52%[8]	21

Worldwide Internet users

	2005	2010	2013[a]
World population[15]	6.5 billion	6.9 billion	7.1 billion
Not using the Internet	84%	70%	61%
Using the Internet	16%	30%	39%
Users in the developing world	8%	21%	31%
Users in the developed world	51%	67%	77%

[a] Estimate.

Source: International Telecommunications Union.[16]

Internet users by region

	2005[b]	2010[b]	2013[a][b]
Africa	2%	10%	16%
Americas	36%	49%	61%

Figure 10: The list of countries by number of internet users

Nigeria is ranked 8th in the world measured by the number of Internet users, thanks to the teeming population of the country.

Country or area	Fixed wired internet subscriptions				Mobile cellular subscriptions			
	Number[4]	Rank	%[5]	Rank	Number[6]	Rank	%[7]	Rank
China	174,285,380	1	13.0	66	231,614,860	2	17.2	75
United States	87,974,583	2	28.0	24	234,412,672	1	74.7	9
Japan	35,556,075	3	27.9	25	144,077,507	3	113.1	2
Germany	27,674,074	4	34.0	13	33,336,214	11	41.0	40
France	24,780,180	5	37.8	8	34,233,625	10	52.2	27
United Kingdom	21,455,580	6	34.0	14	45,419,806	9	72.0	14
Russia	20,630,858	7	14.5	61	75,344,817	5	52.9	25
South Korea	18,354,447	8	37.6	9	51,810,697	8	106.0	4
Brazil	18,275,780	9	9.2	85	73,021,400	6	36.6	44
India	13,701,687	10	1.1	137	59,048,607	7	4.9	110
Italy	13,548,539	11	22.1	45	31,710,663	12	51.8	28
Mexico	12,588,657	12	10.9	76	11,180,208	23	9.7	94
Spain	11,410,276	13	24.3	37	25,044,744	13	53.2	24
Canada	11,282,326	14	32.9	16	17,163,076	19	50.0	32

Figure 11: The list of countries by number of broadband internet users (1)

Uganda	36,332	119	0.1	165	2,542,911	58	7.6	99
Suriname	32,192	120	5.7	98	—	—	—	—
Cambodia	30,653	121	0.2	158	1,032,781	70	6.9	100
Liechtenstein	29,504	122	80.4	1	—	—	—	—
Guyana	28,593	123	3.9	112	—	—	—	—
Angola	27,987	124	0.2	162	278,966	108	1.5	129
Andorra	26,346	125	31.0	22	—	—	—	—
Saint Lucia	22,415	126	13.8	62	—	—	—	—
Maldives	21,718	127	5.5	101	84,700	122	21.5	70
Cape Verde	19,791	128	3.8	113	117,986	114	22.5	65
Mozambique	19,753	129	0.1	168	431,988	94	1.8	127
Brunei	19,650	130	4.8	105	31,080	130	7.6	98
Sudan	18,472	131	0.1	172	5,607,848	31	16.4	78
Chad	18,000	132	0.2	161	—	—	—	—
Cayman Islands	17,750	133	33.8	15	—	—	—	—
Botswana	16,407	134	0.8	143	348,124	102	16.6	76
Bhutan	16,015	135	2.2	124	17,851	133	2.5	122
Nigeria	15,311	136	0.0	185	17,339,012	18	10.2	91
Grenada	14,945	137	13.7	64	—	—	—	—
Zambia	14,785	138	0.1	166	90,643	121	0.7	137
Burkina Faso	14,166	139	0.1	169	—	—	—	—

Figure 12: The list of countries by number of broadband internet users (2)

In the two tables above, the countries of the world are listed by rank in terms of the broadband Internet users.

Broadband is traditionally defined as greater than 256Kbps bandwidth. However, the Nigerian government defines it as greater than 1.5Mbps. Using the traditional definition, Nigeria has very limited ***fixed wired broadband subscriptions*** and is ranked 136th in the world. However, we have a growing number of ***mobile broadband subscriptions***. Ranked 18th in the world, from these figures, it is easy to see that Nigeria has a long way to go.

Another thing to see is what percentage of the population is using broadband. This is relatively small compared to the developed countries.

Nigeria's policy on broadband Internet connectivity

It is well-known that the GDP of a country is indicated by the number of Internet users.

I will use Nigeria as a case study for a developing economy.
The President of the Federal Republic of Nigeria, Dr. Goodluck Ebele Jonathan set out The Nigerian Broadband Vision 2020. Also, this President is the first to establish a Federal Ministry of Information and Communication Technology (ICT). It is commendable that the ministry was created with the appointment of Mrs. Omobola Johnson as a Federal Minister of Communication Technology.

The ministry's website has the document
The Broadband Vision For Nigeria: Vision 20:2020
It states:

> *By 2020, Nigeria will have a large, strong, diversified, sustainable and competitive economy that effectively harnesses the talents and energies of its people and responsibly exploits its natural endowments to guarantee a high standard of living and quality of life to its citizens.*

This Vision reflects the intent of the Federal Republic of Nigeria to become one of the top twenty economies in the world by the year 2020, with a principal growth target of not less than ***$900 billion in GDP*** and a ***per capita income of not less than $4000 per annum***. Pervasive broadband access is a critical requirement for Nigeria to achieve this Vision. The 2013 GDP of Nigeria is $528.1 billion and the per capita income is about $1098 per annum.

In comparison, the 2013 GDP of South Africa is $350.6 billion and that of Egypt is $272 billion. Note that the populations of these three African countries are very different. Nigeria has 2 to 3 times the populations of either Egypt or South Africa.

So we look at the per capita income for comparisons.
The Gross Domestic Product per capita in Nigeria was last recorded at $1097.97 in 2013. The GDP per Capita in Nigeria is equivalent to 9 percent of the world's average. GDP per capita in Nigeria averaged $687.47 USD from 1960 until 2013, reaching an all time high of 1097.97 USD in 2013 and a record low of 468.10 USD in 1968. GDP per capita in Nigeria is reported by the World Bank.

The Nigerian Vision 20:2020 represents a 70% increase in GPD and a 264% increase in per capita income relative to the 2013 data.

Is this Vision achievable in barely 5 years from now? The Internet can play a strong role in the achievement of that Vision. A reliable Internet connection is required in order to achieve this bold and audacious goal. And I might re-iterate that Internet connection should be ubiquitous and FREE !. Especially for tertiary and secondary educational institutions

e.g. universities, secondary schools, etc. However, I believe we need other infrastructure (such as constant supply of electric power and clean water) as well.

The Nigerian Federal Government needs to find a way to make this happen.

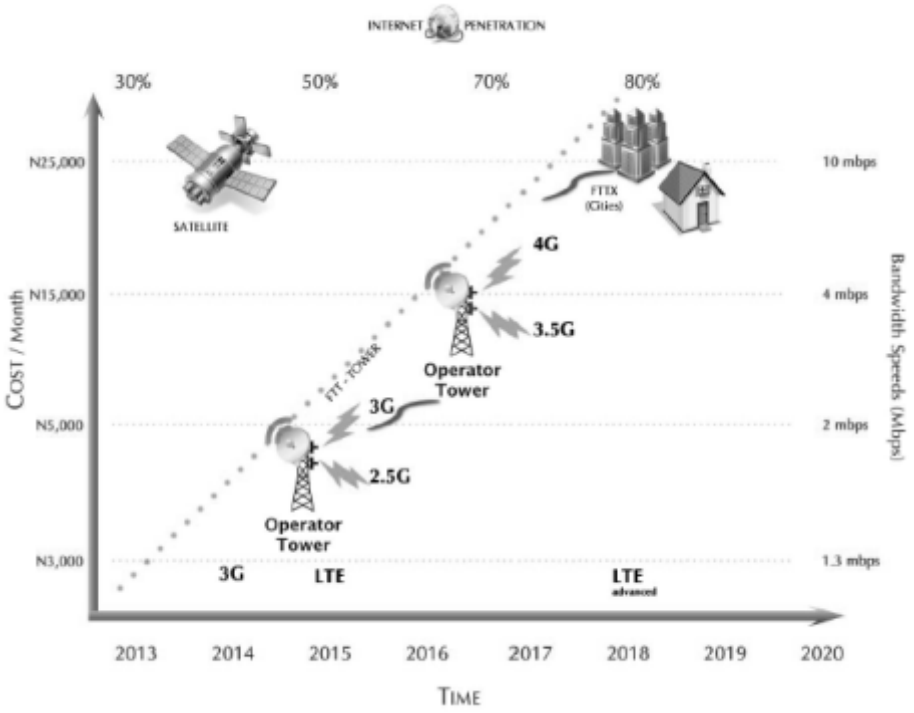

Figure 13: Nigeria's broadband progression chart

Nigeria's broadband progression chart from the Federal Ministry of Communications Technology document is shown in the Figure. It depicts the broadband progression for increased Internet penetration against infrastructure coverage and penetration including available broadband speeds and corresponding price points for those speeds.

THE INTERNET OF THINGS (IOT)

The pace of technological innovation is mind-boggling. Technologies that did not exist just a few years ago are now commonplace and being used to underlie our whole economy from banking to engineering to medicine. For example, Internet/information technology and nano-technologies just to mention a few.

We have said a lot about the "Internet", but many people have not yet heard of the "Internet of Things (IoT)" also sometimes called "Internet of Everything (IoE)".

The IoT has been defined in many ways. Here are some definitions:

"IoT is a mix of telecommunications engineering and computing, encompassing wireless communications, sensors, IPv6 and the computing technologies necessary to run applications over the underlying physical infrastructure."

"IoT is a global network of embedded computers, sensors and actuators connected online through internet protocols."

"IoT is a foundation for connecting things, sensors, actuators, and other smart technologies, thus enabling person-to-object and object-to-object communications or person-to-man and man-to-man (M2M) communications."

"IoT is the next set of technical challenges engineers face in making the internet truly global and more relevant to our daily lives."

"IoT is the next frontier for making money" (This one is my favorite definition!!!)

"IoT is like 1st generation internet multiplied by 5 to 10 times.

Future economic value of connecting things = $19 trillion (size of the US economy)"

➔ this is hard to believe but it speaks to the great promise of IoT.

My preferred definition of IoT:

- Growing network of everyday objects (from industrial machines to consumer goods) that can share information, complete tasks ***un-aided.***
  - Smart devices collect data
  - Relay information or context to one another
  - Process the information collaboratively
  - Prompt humans or machine for further actions
- Capabilities
  - Sensing, Robotics, Communications, Analysis
- Characteristics
  - Ubiquitous, Un-tethered, Un-limited
  - Embedded Everywhere and in Everything
  - Autonomous Smart Life
  - Significantly improve our Lives e.g. in
    - Healthcare
    - Agriculture
    - Home
    - Smart City / Safe City
    - Intelligent Transportation System (ITS)
    - Energy Harvesting
    - Others

What are the things in The Internet of Things? The Figure shows a few examples of such things: a bread toaster, a picture frame, a refrigerator, etc.

Figure 14: Some of the "things" in The Internet of Things?

A fun way to explain the Internet of things in less than two minutes is by using an interesting video from Philip Moynagh, a Vice-President at Intel Corporation. The video is available on YouTube (See https://www.youtube.com/watch?v=C8NMRpZb6Ss).

A brief pictorial history of the Internet of things is also shown in Figure15

Figure 15: A brief history of the Internet of Things (IoT)?

What is IPv6?

In order to be able to address billions and billions of things in the Internet of Things (IoT), we will be giving them unique IP addresses as well.

A new address scheme known as IPv6 (Internet Protocol version 6) has been developed and is required for IoT. The address has 128 bits. This is capable of addressing 2^128 devices. This gives a total of 340,282,366,920,938,463,463,374,607,431,768,211,456 = 3.4 x 10^38 unique addresses. This is much larger than the number in IPv4.

The deployment of the IPv6 protocol began in 1999. IPv6 addresses are 128-bit numbers and are conventionally expressed using hexadecimal strings (for example 2001:0db8:582:ae33::29).

Both IPv4 and IPv6 addresses are generally assigned in a hierarchical manner. Users are assigned IP addresses by Internet service providers

(ISPs). ISPs obtain allocations of IP addresses from a local Internet registry (LIR) or National Internet Registry (NIR), or from their appropriate Regional Internet Registry (RIR).

Potential Impact of the Internet of Things

The potential impact of IoT is huge. Some are predicting a $20 trillion dollar economic effect. Regardless of the financial picture, it is certain that many of the following areas will see tangible changes due to IoT such as changes in Medicine and Health care, Smart Cities, Agriculture, Education, Manufacturing, etc.

Video Clips

References in the Appendix list some video clips from YouTube and other sources that help educate and illustrate the potential of Internet of Things (IoT).

In this lecture, I only have time to play a few of these videos. You can check out the other videos from the references. Here they are:

- IoT Videos
  - IoT Dream Future: http://youtu.be/ujk1cprLpD8
  - IoT Social Networks: http://youtu.be/i5AuzQXBsG4
  - Goldman Sachs: http://www.goldmansachs.com/our-thinking/outlook/iot-video.html?cid=PS_02_89_07_00_00_00_01V
- Imagine Everything was Linked
  - http://youtu.be/igsJxXMssGA
  - http://youtu.be/__pkZ4-kNvY
  - http://youtu.be/tvpRJrQ8Z2c
- The Internet of Things explained in 2 minutes
  - https://www.youtube.com/watch?v=C8NMRpZb6Ss

BIG DATA : A HUGE CHELLENGE FOR THE INTERNET OF THINGS

What is Big Data?

- Big Data = A collection of data sets so large and complex that it becomes difficult to process using traditional methods
- Examples:
  - How much data is all the music recorded on Apple's iTunes?
  - How much data is all the videos on Google's YouTube?
- We continue to generate tons and tons of data !!!

Here's a quote from Eric Schmidt, former CEO of Google, Inc.

"*From the dawn of civilization until 2003, humans generated 5 exabytes of data.*

Now, we produce 5 exabytes every two days. .....and the pace is accelerating."

- The **exabyte** is a multiple of the unit byte. The prefix exa indicates multiplication by the sixth power of 1000 or 10^18 in the International System of Units (SI). Therefore one **exabyte** is one quintillion bytes (short scale).

How do we generate these Big Data?

Sensors (video cameras, microphones, music instruments, etc.) are everywhere leading to data explosion

- We live in an age of data explosion
- Data Centers are being built that store trillions of bytes of information about us and about things.

What US companies are doing for IoT

- Google has come up with Android for Home IoT, building driver-less cars, etc.
- Cisco is making networking hardware for IoT
- Intel is making Integrated Circuit (IC) chips for IoT
- ARM is building the new Internet architecture for IoT, (see www.mbed.org).
- Even Banks and investment companies like Goldman Sachs are getting involved

OPPORTUNITIES FOR DEVELOPING COUNTRIES

I believe there are opportunities for developing countries to utilize the Internet and the Internet of things (IoT) technologies to leapfrog themselves into the developed economies. The IoT is a nascent area from where developing countries can benefit.

Not all problems in developing countries require high-tech solutions. Some low-tech solutions will do just fine.

For example, the **Frugal Innovation Lab at Santa Clara University** (SCU), develops *accessible, affordable, adaptable, and appropriate technologies, products and solutions to address human needs in emerging markets such as in developing countries.*
(see www.scu.edu/engineering/frugal)

In addition, the people in developing economies most of the time cannot afford to pay the high prices for the latest high-tech products. So, they can either wait until the prices go down enough (thanks to Moore's Law) or they can deploy low-tech, low-cost solutions to their problems that the population in most developing countries can afford.

Even US businesses are looking at making money by selling lots of low-tech devices to a lot of people. The business models of companies like McDonalds hamburgers (or Mr. Biggs' fried rice) are good examples. They make money by selling food (a product we all need about three times a day) to millions of customers. So even if the margin on each hamburger they sell is 5 cents (10 naira), if they sell one million hamburgers in one day, that is $50,000 profit in one day.

That is what Frugal Innovation is all about.

OPPORTUNITIES FOR COVENANT UNIVERSITY

Covenant University Smart City Development

This is about developing the Covenant University (CU) campus into a Smart City as a model for other bigger cities' Smart City Development efforts. CU can develop a prototype IoT Smart City for Nigeria and Africa.

The New Bachelors degree programme in Internet of Things (IoT)

Here at Covenant University, we have proposed a new innovative undergraduate engineering Bachelor's Degree Programme in the Internet of Things (IoT). This will be the first such degree programme proposed in Nigeria (and perhaps in Africa).
The Degree Programme is officially known as the **"B.Eng. Internet of Things Engineering"**.

Philosophy, Aims and Objectives of the Degree Programme

The main ***aims and objectives*** of the Bachelors Honours Degree Programme in IoT Engineering are to:

create in students the awareness of and enthusiasm for communication engineering, computer engineering and science and their capabilities;
involve the students in an intellectually stimulating and satisfying experience of learning and studying;
provide a broad and balanced foundational knowledge in communication engineering, computer engineering (and science) and relevant practical skills;
develop in students through an education in communication engineering, computer engineering (and science) a range of transferable applicable skills of information technology to all aspects of human endeavours;
generate in students an appreciation of the importance of the computer in an industrial, economic, technological and social context; and
to provide students with the knowledge and skills base for further studies in communication engineering, computer engineering (and science) and/or multi-disciplinary studies involving same.

Our new Bachelor Programme is designed to ***equip students with***:

a thorough knowledge of telecommunications and computer science;
an understanding of network design and network planning principles for IoT;
a knowledge of theory, methodology and techniques for IoT network assessment and evaluation;
a good overall understanding of computer and telecoms network development skills;
knowledge of the opportunities accruable from the monetization of the *IoT* in a developing economy.

To enable us to produce top IoT engineers, we have introduced ***new courses*** in these new areas:

Cryptography Principles & Applications, Computer and Network Security, RFID Systems, Cloud Computing, Web technologies, Operating and Database systems, Wireless Sensor Networks and Internet of Things (IoT) Engineering.

We have strengthened ***existing courses*** such as :
Advanced Mathematics, Computer Fundamentals and Programming, Data Structures, Digital Circuit Design, Digital Signal Processing, Microprocessor Systems Design, Computer and Network Security, etc.

One example of description of one of the new courses we have proposed is as follows:

IoT 416 Internet of Things (IoT) Engineering (2 Units)
Basic Principles of the IoT architectures for IoT major engineering students.

This course teaches students the design principles of the Internet of Things (IoT) and their device and infrastructure-related architectures, technologies and protocol frameworks which are being designed to enable the formation of highly distributed and ubiquitous networks with seamlessly connected heterogeneous devices. Students will also analyze such networks.

The networks will support the development of intelligent services with given performance requirements in a variety of application domains.

Some of the detailed topics include:

major architectures and paradigms for the Internet of Things;
protocols at the different levels of the IoT stack; and also
how to map those concepts with the OSI model by means of

- medium access (MAC) layer (including sensor, vehicular and cellular networks for machine-to-machine communication);
- network layer (with particular emphasis on IPv6-based solutions); and
- technologies and protocols at the service and application layers, which enable the integration of embedded devices in web-based, distributed applications.

Learning Outcomes

Upon completion of this course, students should be able to:

1. Characterize the Internet of Things (IoT) and enumerate its distinctive characteristics.
2. Demonstrate understanding of IoT and major machine-to-machine (M2M) communication protocols.
3. Demonstrate understanding of network layer support of IoT.
4. Design solutions for integrating smart objects into IoT framework(s).
5. Design IoT services and evaluate and analyze performances of IoT systems.

The 5-year Degree Programme in IoT Engineering will be in addition to existing programmes in Computer Engineering, Electrical and Information Engineering and Electrical and Electronics Engineering.

This new curriculum proposal will be subjected to the usual procedures for curriculum adoption in the University and finally ratified by The University Senate. Upon approval by both the Senate and Governing Council, the National Universities Commission (NUC) will be invited for resource verification on the establishment of this new Programme. It is only after this stage that the Programme can be incorporated into the University curriculum.

After the National Universities Commission has adopted this new curriculum, then the impact will already be national as it would have enriched the curriculum base of Nigerian universities.

We also plan to offer MS degree programmes with a specialization in Internet of Things.

Why the B.Eng in IoT now?

By the year 2020 (five short years from now), between 30 to 50 billion devices will be connected to the Internet of Things (IoT). This is approximately about six Internet things (devices) per person.

This will be made possible in part:

Through advancement in Sensor technology, BWAN, SON, cloud computing, etc.

Through the adoption of the IPv6 scheme which can accommodate 3.4 x 10^38

340,282,366,920,938,463,463,374,607,431,768,211,456 unique IP addresses

With this many IP address for IoT, we can conveniently assign 100 unique addresses **to each atom** on Earth.

There is money to be made in new products and services which are not even imagined yet. It is expected that the IoT market will be in excess of $1,423.09 Billion USD by 2020. This is a new market with equal opportunities for everyone who will be well equipped to access it. ***Just like people have made and continue to make money from the Internet, there is a lot of money to be made from the internet of things (IoT).***

The 'Things' to be interconnected will have to be designed, constructed and built by specially trained Engineers, Technicians, Technologists in ways as to make them extremely miniaturized, energy efficient, environmentally friendly, 'green' and sustainable.

The existing curricula of most universities were not designed to address this market specifically, as indeed it could not have been.

This is a great win-win endeavour for Covenant University (CU). CU Engineering students trained in IoT can develop Embedded Systems for IoT (using Intel, ARM, Sensinode, CISCO, etc. products). They can develop new ways to use all the Big Data generated by IoT. New companies will emerge.

IoT presents a great opportunity for developing countries like Nigeria to catch up with the developed and industrialized world by leapfrogging in technology. An example of that was how mobile phone has enabled these countries to catch-up in the field of telephony with the rest of the developed world. Instead of laying copper cables for land lines for fixed-telephones, we can now either lay optical fibre lines to each house or just go wireless for out telephony needs.

The New Pedagogies to be Deployed at CU

As we develop this new curriculum, we also want to take advantage of new learning approaches and paradigms. Such novel paradigms in instruction and learning include:

problem Based Learning (PBL) - for enhanced critical thinking;
project Based learning - for enhanced creative thinking;
flipped classroom; etc. is a requirement in this curriculum development project.

On Education of the Next Generation of Professionals

The education of the next generation of professionals in any field (especially in engineering) should keep pace with the rate of technological innovation. There is an urgent need to re-think the way we educate our students to take advantage of these new technologies of

educational delivery and adapt our curricula to better deliver the educational experience and mastery necessary to produce top professionals in any field. Technology can help !

The teaching methods should no longer be "***A sage on the stage***" way or the "***chalk and talk***" way. The bottom line is that people learn in various ways and at various times. Therefore, teaching should be delivered in many different ways, with convenience of media and flexibility of schedules.

Education is also another area where we can leapfrog to catch up with the developed world. The importance of education can never be over-emphasized. I believe that education holds the key to a developed Africa that will command the respect of the world.

One tool we can use to leapfrog in education is the idea of Massive Online Open Courses (MOOCs). MOOCs are online tools that deliver high-quality instruction (to thousands of people at a time) anywhere and at any time. From anywhere in the world, you can take a Stanford University course taught by a renowned professor without setting foot on the Stanford campus. All you need is a computer and broadband Internet access. You even make friends online from your "classmates" all over the world through online discussion groups.You get to "meet" several "classmates" online and share experiences and learn from one another.

Examples of the so-called MOOCs are Coursera (Stanford and other universities), EdX (MIT and Harvard), Udacity (former Stanford professor), etc. In addition, we can utilize various virtual labs such as MIT's iLab. and other available online courses

For example, Nigeria can move quickly towards that future by making sure we have broadband Internet connectivity in all towns and villages.

Covenant University can also act as a laboratory for a prototype for setting up this future in Africa. For example, CU can be a model learning centre using the latest learning technologies: a model educational institution where learning can be online and interactive.

The paradigms are changing. Information is readily available through the Internet. In fact, we sometimes may suffer from too much information. A simple Google search on any topic typically yields many million results. The job of the teacher or lecturer will then be to help the student make sense of that information.

This is the essence of the flipped-classroom. For example, a lecturer can have students view online lectures, then discuss what they watched in class to complete the instruction and then spend more of the class time on solving problems and helping students learn. This I believe will be part of the future of learning.

CLOSING THOUGHTS

I wish to share a few thoughts with you in closing:
The US President has started an initiative aimed at young African leaders. It's called the Young African Leaders Initiative (YALI), launched in 2010.

The goal is to target hundreds (initially about 500) of promising leaders from Sub-Saharan Africa between the ages of 25 and 35. They are invited to a 6-week programme to develop their skills. The programme teaches:

(i) Entrepreneurship
(ii) Civic leadership and
(iii)Public management

It teaches how to build grassroots organizations, how to run a business, etc. More at www.yali.state.gov

The response to YALI's call for participants was overwhelming. Next year's YALI event will be held in Africa. (It will be wonderful to bring the workshop to CU or host it in Nigeria).

One of the African attendees of the YALI town hall meeting asked President Obama this hypothetical question.

Question: As the first African-American President of the United States of America, what would you say to the President of the ***United States of Africa***? (Personally, I don't think the dream of Nkrumah of a United States of Africa will ever be realized).

President Obama gave one of his signature long-winded answers, but I think an excellent one from which we can learn a lot. I beg your indulgence for me to read his response.
He said and I quote:
Answer:
...Begin quote...
"The first issue I will emphasize is the issue of
1.
Governance.
How to govern? Who is the US to tell us how to govern? Different systems, different cultures, etc. US system is not perfect. I understand all that.

Regardless of how much resources a country has.
Regardless of how talented the citizens are.
If you do not have a basic system of rule of law
Respect for civil rights and human rights.

There has to be a credible legitimate way for a country and individuals to work through and express their political aspirations,
If you don't respect basic
Freedom of speech, freedom of assembly.
Put laws in place in which every one is equal under the law.
No one set of rules for the wealthy and another for the poor.
If you do not have an economic system that is transparent and accountable so that people trust that if they work hard, they will be rewarded for their work, and corruption is rooted out,
If you don't have those basic mechanisms, it is very rare for a country to succeed.
.....I will go further than that, and say the country will not succeed over the long term.
It may succeed in the short term, because it may have natural resources that it can extract and it can generate enough money so that it can distribute and create patronage networks but over time, that country will decline.
If you look at examples around the world, you will have a country like Singapore,
Which has nothing, a small tiny city-state, it has no real natural resources,
And yet it's taken off.
And you have other countries, which I wont mention that have incredible resources,
But because there is no system of laws that people have confidence in, it never takes off.
Governance alone is not sufficient. It is a starting point.
You have to have an
2.
Education system
3.
Infrastructure

There are other elements, but If you don't have the basic premise…that Ordinary citizens can succeed based on their individual efforts,
That they don't have to pay a bribe in order to start a business or even to get a telephone, that they wont be shaken down when they're driving down the street because police officers aren't getting paid enough. And this is the accepted way to supplement their income…if you don't have those things in place, then over time, there is no trust in the society.
People don't have confidence that things are working the way they should
And so then everybody starts to figure out, OK, what's my angle? How am I going to
get my thing?
It creates a culture in which you cant really take off.

You're never going to eliminate 100% of corruption. Here in the United States, occasionally we have to throw people in jail for taking money for contracts or having done favors…for politicians.
All that's true but the difference is that here in the United States, and in many of the more developed industrialized countries, it is more the aberration rather than the norm.

The truth is here in the United States, if you want to start a business, you go ahead you file a paper, you can incorporate. You might have to pay a fee, $50 or $100 or whatever it ends up being charged, That's it, you got your business.
Now, the business might not be making any money at that point,
You still need a whole bunch of stuff to succeed, But the point is basically the rule of law is observed.
That's the norm. That is what happens 95% of the time.
That's where you have to start. That is why young people have to have high expectations for their leadership.

And don't be fooled by this notion that we have a different way, the African Way,
Well, no. The African way is not that after you have been in office for a short time,
You suddenly have a Swiss bank account of $2 million.
That's not the African Way.

And part of the rule of law is that leaders eventually give up power over time. It does not have to be the same way all the time.
But if you have entrenched leadership forever, Then what happens over time is that
You don't get new ideas, new blood and it is inevitable sometimes that the rule of law becomes less and less observed because people start being more concerned about keeping their positions than doing the right thing."
……End of quote…..

My first reaction to this response was that this is the first time I see an American president that really has a good understanding of the issues African countries are facing
and is trying to help Africa develop. Previous US Presidents will perhaps not be so brutally honest with the Africans.

But we, Africans have to take the measures he prescribed in order to get the results we want.

After he gave the example of Singapore, I also wondered if the other country he refused to name was Nigeria? It seems to me that Nigeria fits the description he gave. It is true that Nigeria has a lot of resources (more than Singapore). Also, Nigeria has a lot of talented people (many in this audience).

Does Nigeria have

(i) Good governance?
(ii) Good education system?
(iii) Good infrastructure?
(iv) Rule of law?
(v) Free of corruption?
(vi) Free of entrenched leadership that is there forever?

I sure hope the elections in a few days will usher in an era of good governance.

What can we say about Nigeria's educational system? It needs big improvement especially in public education. That is why private institutions are attracting a lot of students at the expense of public ones.

What about Infrastructure? Rule of law? Corruption? Entrenched leadership?

Is there really an African way to develop? In as much as we have African cultural differences from American or other countries', I don't think there is an African way to develop. The basic ingredients itemized here are necessary for any developing country to take off.

Now let us all go and do the right thing. May God help Nigeria to finally take off.
Thank you for listening.

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I thank all of you for attending this public lecture.

Dedication:
This lecture is dedicated to the memory of Mr. Lanre Amos, one of the most brilliant people Nigeria ever produced.

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