HISTORY OF WIRELESS TECHNOLOGY by Momah Ego Nkiruka (Member No: 41565356)

Abstract

Evolution of the Wireless technology is based on the breakthroughs in engineering science made by several pioneering giants during the 19th century and also at the early part of the 20th century. Developments during that time form the bedrock of our present civilisation in communications technology. As the myriads of contributions to this field cannot be covered by the scope of this paper, only key developments will be hitherto discussed.

With a bit of history dating back to Hans Christian Oersted (1819) and Andre Marie Ampere (1820), who were credited with discovering that electricity could produce magnetism, coupled with the ingenious discovery of Michael Faraday (1831) that magnetism could produce electricity, all these lead the candle of advancements in communication technology to the discovery of James Clerk Maxwell and experimental validation of his four laws by Heinrich Hertz to the commercialisation of these concepts by Guglielmo Marconi through transmission into space by radio waves which Guglielmo referred to as the “wireless”.

The late 19th Century

The true history of the wireless may be traced back to the work done by James Clerk Maxwell. Born on 13th of June 1831, his contributions to science affect us everyday. At the age of forty-two, he discovered the science of electromagnetism and presented his initially controversial four equations now popularly known as Maxwell’s Equations. His theory of electromagnetic radiation opened the door for the use of radio waves for radio, television and personal mobile communications amongst others, and led directly to the discovery of radio waves by Heinrich Hertz.

Maxwell deduced that electrical and electromagnetic phenomena acted through waves. Using his equations, he showed that these waves (which are commonly called **radio waves**) were both electrical and magnetic in nature. Hence, Maxwell himself said (as quoted in his work, "On a dynamical Theory of the electromagnetic field", 1865) [4] that “we have strong reason to conclude that light itself including radiant heat and other radiators if any, is an electromagnetic disturbance in the form of waves propagated through the electromagnetic field according to electromagnetic laws.” His mathematical equations are expressed as follows [4]:

<u>Electric Force</u>

$$\nabla \cdot D = \rho$$

This equation expresses that an electric charge is a source of an electric field, that is, electric lines of force begin and end on electric charges.

<u>Magnetic Force</u>

$$\nabla \cdot B = 0$$

This equation shows that there are no isolated magnetic charges.

<u>Electromagnetic Induction</u>

$$\nabla \times E = -\partial B / \partial t$$

Voltage is generated in a conductor as it passes through a magnetic field (or cuts magnetic lines of force). This was Faraday's great discovery of 1831.

Magnetic Effect of Electric Current

$$\nabla \times H = J + \partial D/\partial t$$

This equation verifies the fact that a magnetic field can be produced not only by current but also by a time-varying electric field. This was the conclusion that Faraday had derived from Oersted's experiment.

Before this statement of his theory, few people suspected the existence of electromagnetic waves and even less could ever have imagined the vast impact these waves could have on humanity. It was said by Sir J.J. Thompson (1931) in [4], "The discovery of electrical waves has not merely scientific interest though it was this alone which inspired it. Like Faraday's discovery of electromagnetic induction, it has had a profound influence on civilization, it has been instrumental in providing methods which may bring all the inhabitants of the world within hearing distance of each other and has potentialities, social, educational and political which we are only beginning to realize".

Experiments carried out by Professor Heinrich Hertz of Germany revolutionised the use of radio and antennas in modern communication technology. This turning point occurred between 1886 and 1888 at about the age of thirty when he detected and discovered non-optical waves. It was his work, which clarified and expanded the electromagnetic theory of light that had been put forth by J.C Maxwell about fifteen years earlier. Hertz proved that electrical energy could be transmitted in the form of electromagnetic waves with travel at the speed of light. The waves possessed many of the properties of light. They could be polarized, reflected and refracted. Hertz used an end-loaded half-wave dipole as the transmitting antenna and a resonant half-wave receiving loop operating at a wavelength of 8 meters to produce what is known as short radio waves. He focused the waves with a reflector and showed their presence by means of sparks in the wire loop gap that was a few meters away. Hertz died a few years after this at the age of thirty-seven and the unit of frequency was renamed after him.

Whilst Heinrich Hertz' experiments remained a laboratory curiosity, it was Marconi's invention that gave birth to the wireless technology. In fact, it was when reading an account of Hertz' work that young Marconi came upon the idea of using the Hertzian waves as a means of communicating without wires. In 1895, Guglielmo Marconi began laboratory experiments at his family villa in Italy where he succeeded in sending wireless signals over a distance of one and a half miles. Thus, he became the inventor of the first practical system of wireless telegraphy.

In 1896, Marconi took his equipment to England where he was granted the world's first patent for a system of wireless telegraphy. There in London, he successfully made his first public demonstration of wireless telegraphy. By July 1897, he had formed the Wireless Telegraphy and signal company Limited (which was later renamed Marconi's Wireless Telegraph Company Limited).

Although it is widely believed that Guglielmo Marconi was the inventor of the radio, the contributions made by Alexander Popov, a Russian Professor, cannot be ignored. Almost at the same time in 1895 when Marconi was making his new invention, Popov sent and received a wireless signal across a 600 yards distance. His aim, actually, was to develop a thunderstorm detector but instead, Popov's thunderstorm detector became a receiver of radio waves. In this way, Popov also was an inventor of the radio.

Russian history sources say that Popov's wireless equipment was used to help a sea vessel in distress. The sailors, in order to make contact with wireless stations on land used Popov's radio system, which was aboard the vessel. Those wireless stations relayed the messages and rescue order to the appropriate service. This was the first ever use of radio communication.

Wireless Technology in the 20th Century

History was made in wireless communication at the turn of the 19th century into the 20th century. Thirteen years after Hertz discovery in 1888, on the 12th of December 1901, Guglielmo Marconi - also known as the “wizard of wireless” - jolted the world by transmitting wireless signals across the Atlantic between Poldhu, Cornwall and St. John’s Newfoundland. It was a feat that covered a distance of about 3500 km. The transmitting antenna consisted of several vertical wires in the form of a fan connected to ground through a spark transmitter. The receiving antenna at St. John’s was a long wire, which was pulled and supported by a kite. This transmission was proof that a message could be sent forth on an electromagnetic wave, bending over the sea as the earth curved and travelling at the speed of light. What was transmitted was a series of Morse code signifying the letter “S”.

However, it was in October 1902 that the first verifiable transatlantic radio transmission was made. It was a transmission with a frequency of about 275kHz and made from Poldhu, Cornwall to aboard a ship harboured at Sydney. Again, this was a feat accomplished by Mr. Marconi.

A century ago, Sir John Ambrose Fleming, while working as a consultant to Marconi’s telegraph company, discovered the practical application of the diode for detecting and rectifying alternating current radio waves. The diode was made up of a heated element in an evacuated glass bulb. A second element was also placed in the bulb but not heated. It was found that an electric current flowed only in one direction with electrons leaving the heated cathode and flowing towards the anode and not in the other direction.

The first diode was actually invented by Thomas Edison when he observed that carbon particles were deposited on the inner surface of a bulb operating at a high voltage. Edison however did not pursue these experiments further to discover any practical applications. Sir Fleming did this and his diode is referred to as the “Fleming Valve”.

This invention led directly to the development of the triode, a diode with an added grid structure. In 1906, Lee DeForest invented the “Forest-triode” while working at improving the amplification of radio receivers. Unfortunately, DeForest was not certain of the exact working of the triode and so he attributed its amplifying function to the gas contained in the tube. This erroneous explanation led to a patent litigation after his invention. The triode though, was used in communication and broadcasting and served to amplify the signals.

Reginald Fessenden successfully accomplished human voice transmission by wireless means in Dec 1900. Until this time, the only known transmission was in Morse code. Hence this was another milestone achieved in the history of the wireless. By 1906, he had constructed a means to successfully transmit the human voice over longer distances and his communication apparatus was a high frequency alternator of 100kHz.

From then on, wireless technology began to advance in leaps and bounds with several accomplishments by various individuals. Magnus Ericsson and his wife Hilda in 1910 used the first car telephone, which consisted of two long sticks over a pair of telephone exchange.

Various signal detectors and radio generators were invented and improved for the transmission and detection of radio waves. A detector called the “Coherer” was the work of several men inclusive of A. Popov and Oliver Lodge to mention a few. The coherer consisted of a small quantity of metal filings lying loosely between metallic electrodes and enclosed in a glass tube. The whole apparatus was then enclosed in a metallic box. Marconi used this coherer for telegraphic purposes. These detectors of wireless signals could broadly be classed as potentially activated detectors and current actuated ones. Other detectors, apart from the detector used by Marconi, included the Fleming valve and those of Fessenden and Schlomich, which were electrolytic in nature.

The 1920s brought about significant improvements and further developments in wireless technologies. Broadcasting entertainment and news transmissions using radio was made by the Marconi Company in February 1920. Police car radios and walkie-talkies were used for the first time in New York and Detroit, and in Britain, the British Broadcasting Company (BBC) was formed.

Up until this time, long distance communication had been on long waves while transatlantic communication was either by cable or by mail. The cable system was quite limited by its capacity and monetary costs while communication by mail could be very slow business, as it was by ship, taking up to several weeks for the mail to arrive at its destination. With high frequency transmission, transatlantic communication would be faster with higher capacity systems and also quite affordable to use. Hence, it was another memorable event in the history of the wireless when in October of 1924 transmission was made from a station at Mill Hill London to one at Dunedin, New Zealand using short waves.

World War 2 proved to be significant in the development of the wireless and wireless technology eventually progressed to be an invaluable tool used by the military for warfare. It was recognized that higher capacity systems were needed and hence during the war, radio communication went up to even higher frequency bands. Military leaders also configured wireless signals to transmit data over highly complex encryption media. This made unauthorized access to the system nearly impossible and by this, the army could transmit battle information over enemy lines. The Germans used Enigma machines for encoding their secret military information to be sent to outposts. With Enigma, messages could easily be translated into 5 (five) letter groups that were transmitted in Morse code and then decoded by a machine using the same settings. Unfortunately, these machines had over 150 000 000 000 000 settings which made the task of decoding for the British code breakers a Herculean one.

Bletchley Park (codename Station X) became the base for the British code breakers during the war. Bought in 1939, it was disguised to appear as a hospital so that its actual purpose was kept secret. It was actually the base for the UK Government Code and Cipher School responsible for the interception and decryption of enemy transmissions. Had the Germans ever caught wind of the actual work being done at Bletchley Park, they would most likely have destroyed the place. Thousands of young people recruited to Station X were warned strictly to keep the mission of the place secret, only if it became extremely necessary were they to tell their wives.

Alan Turing, one of the most brilliant mathematicians of his time, became the first code breaker to decipher the Enigma codes. The success of the code breakers at Bletchley Park is viewed to have shortened the length of the war by several years. Bletchley Park has been an enigma for many years. It is only recently (1993) that it was opened to the public and there are several published works in print today on the puzzle of the Enigma.

Development of the RADAR system was accomplished during the early part of the War and antenna technology, which was centred on radiating wire elements moved up to new antenna elements such as the reflectors and the horn antennas. The development of these components to operate at the higher radar frequencies led to the development of very high frequency and ultra high frequency radio systems.

Mid 20th century brought along the advent of the space program. Dating up to this period, all international communications relied on either short wave radio transmissions or cable links. Both methods had its limitations; hence the need for more improved means of communication. In 1945, Arthur C. Clarke authored an article in the "Wireless World" in which he proposed a system that would eventually become geo-stationary satellites. They are called geo-stationary because the positions of these satellites would appear motionless from the ground. Signals would be transmitted up to the satellite that would rebroadcast them back to the earth. In view of their altitude above the earth, the signals would be able to be received many thousands of miles away from the original transmitting station. Clarke calculated that satellites placed in a high orbit of 36,000 km would take exactly one day to go around the Earth. Therefore, a minimum of three satellites, capable of receiving and transmitting radio signals and stationed 120 degrees apart, would enable almost total global coverage.

His idea was revolutionary, and although it took many years before the technology was available for it to be implemented, it led to the advent of communication via satellites.

A major step forward in the development of satellite communications came when President D. Eisenhower approved a plan to orbit a scientific satellite as part of the International Geophysical Year (IGY) for the period, July 1, 1957 to December 31, 1958. It was to be a cooperative effort to gather scientific data about the Earth and the Russians expressed their desire to be a part of this. The Naval Research Laboratory's Project, the Vanguard, was selected to represent the United States effort to support the IGY and Project Vanguard enjoyed exceptional publicity throughout the second half of 1955, and all of 1956, but the technological demands upon the program were too great and the funding levels too low to ensure success.

The launch of Sputnik 1 in October 1957 happened in the wake of the Cold War between the United States and the Soviet Union. It was a historic event that brought panic to the Americans while boosting the international image of the Soviet Union. Sputnik 1 had beaten the Vanguard satellite into space.

Sputnik 1 was the world's first artificial satellite to orbit the earth and its size was about the size of a basketball. Weighing only 183 pounds, it took about 98 minutes to orbit the Earth on its elliptical path. Although the satellite fell from orbit three months after launch, its launch and subsequent transmission proved that communication via satellite was possible. That launch ushered in a new dimension in the development of wireless technologies that was political as well as scientific. Even before the effects of Sputnik 1 had worn off, the Soviet Union struck again. On 3 November 1957, less than a month later, it launched Sputnik 2, which carried a dog, Laika. While the first satellite had weighed less than 200 pounds, this spacecraft weighed 1,120 pounds and stayed in orbit for almost 200 days.

The Sputnik launch led to the launching of America’s first satellite, Explorer 1. Explorer 1 recorded the discovery of magnetic radiation belts around the Earth that came to be named after principal investigator, James Van Allen, as the Van Allen Radiation Belt. The creation of the National Aeronautics and Space Administration (NASA) by the Americans was also the aftermath of the Sputnik launch and in July 1958, the United States Congress passed the National Aeronautics and Space Act, which created NASA, from the National Advisory Committee for Aeronautics (NACA) and other government agencies. NASA was equipped to coordinate all aeronautical and space activities of the US and to run national and space administrative affairs.

The launch of the Telstar, another communications satellite, proved to be a major milestone in the development of satellite communication. On the 23rd of July 1962, it was used to make the first live transatlantic television transmissions. Signals from the USA were seen live in many homes around Europe, making communication history. The Relay, another satellite, was used to transmit pictures of the funeral of the Late President J.F. Kennedy to people all over the world. Since then the number of satellites has considerably increased, along with improvements in its technology. Today, most international communications are routed via satellites. Telephones and computers are used to communicate around the world via many satellites situated in the geo-stationary orbit. Weather forecasting has also undergone a revolution because of the availability of pictures from geo-stationary satellites. Satellite communication also provides many other useful functions including navigation, geological surveys as well as direct television broadcast.

Wireless technology has evolved into a ubiquitous technology found all over the world. Millions of people today rely on the use of cellular phones, pagers and cordless telephones to communicate. The first operational cellular networks were based on an analogue cellular standard known as the Nordic Mobile Telephone (NMT) and it was first installed in Sweden, Denmark, Norway and Finland. Later to be adopted by the US was the Advanced Mobile Phone System (AMPS).

Analogue systems were faced with the challenge of being unable to handle the growing capacity need in a cost-efficient manner. As a result, digital technology was introduced with its several advantages over the analogue system including ease of signalling, lower levels of interference and an enhanced ability to meet demand for capabilities.

Today, the cell phone is an extremely sophisticated radio. The ingenuity of the cellular system lies in the division of a geographical area into ‘cells’ with each cell having its own base station that tracks and operates cellular phones within its area. Hence as users travel across cells, their conversations are transferred from one cell to the other without interruption to service.

Conclusion and Recommendation

The advent of the Global System for Mobile Communications, an offshoot of wireless technology, has brought with it a source of income for many Nigerians. As it is currently the most widely adopted and fastest growing digital cellular standard in the country, many people are seen to hand out their mobile phones for public use at a stipulated price per minute. The sale of recharge cards by the locals is also a common sight. The business is popularly known as “GSM business” or “phone centre”. So far, this has been a lucrative business.

The use of wireless technology may prove to be a very useful means of saving the lives of many in developing countries, especially in Nigeria. It is a matter of common occurrence in Nigeria today, to find trailers and buses parked on the roads at night, with no indication whatsoever to forward moving vehicles of their presence. Furthermore, a large percentage of cars do not have brake lights that work. These prevalent situations have led to the loss of many lives and damage to property. Hence the use of anti-collision radar to provide anti-collision warning is recommended for vehicles in Nigeria. This radar system could be installed in vehicles and automobiles to alert drivers of other vehicles ahead that are either decelerating too fast or have stopped without warning.

The Nigerian government should also take a queue from the way the Americans view science. As is seen from the incident of the Sputnik 1 launch, when they (the Americans) have a challenge, they immediately work at finding a lasting solution to it. Nigerians should jettison the burden of being a consumer country by contributing to the development of science in the world. This we have already begun to do as is seen by the recent launching of the first Nigerian Satellite.

In conclusion, the wireless has already been useful in the saving of many lives in the world. Its future development can prove to be more beneficial.

REFERENCES

1. Kraus J.D., "Antennas since Hertz and Marconi", IEEE Transactions AP-33, No.2 1985, pp 131-137.
2. Kraus J.D., "Heinrich Hertz – Theorist and Experimenter", IEEE Transactions Microwave Theory Tech, Hertz centennial issue, MTT-36 May 1988.
3. Balanis C. A., "Antenna Theory: Analysis and Design", 2nd Edition John Wiley and Sons 1997, pp 19-22.
4. www.ieee.org/organization/history-centre/general_info/lines_menu.html
5. http://securehosts.com/fech/popov.htm
6. http://www.webstationone.com/fecha/max.htm
7. http://www.webstationone.com/fecha/hertx.htm
8. http://www.webstationone.com/fecha/marconi.htm
9. http://www.nobel.se/physics/laureates/1909/marconi-bio.html

10. http://www.umtsworld.com/umts/history.htm
11. http://www.bbc.co.uk/history/war/wwtwo/enigma_03.shtml
12. http://www.nationmaster.com/encyclopedia/World-War-II
13. http://www.euronet.nl/users/keesree/radio.htm#Invention
14. http://www.nationmaster.com/encyclopedia/Enigma-(machine)