EQUIPMENT GRAFTING IN TELECOMMUNICATION INDUSTRY (CASE STUDY NIGERIA PSTN)

AHANEKU, M.A.
(Communications Engineering)
Department of Electronic Engineering, University of Nigeria, Nsukka.
Email: ahamac2004@yahoo.co.uk

ABSTRACT

The growth and pace of any industry is a veritable estimation of its viability. The telecommunications industry all over the world is ever burgeoning. Its growth is buoyed by development and technologies. These innovations do not necessarily have to instantaneously supplant the old rather they are procedurally applied to the existing network in the form of Upgrades and Expansion efforts. This paper appraises these grafting processes. It introduces the subject matter, highlights the performance capabilities and usage constraints of a variety of switching and transmission equipment. It also gives insight into the on-going grafting efforts in NITEL.

KEY WORDS: Grafting, Switching, Transmission, and Signaling.

1. INTRODUCTION

Telecommunications is one of the fastest growing business sectors of modern information technology. Today, the field of telecommunications encompasses a vast variety of modern technologies and services. Some services, such as the fixed telephone service in developed countries, have become mature, while some others like cellular mobile communications and the Internet have been exploding. The deregulation of the telecommunications industry, coupled with decreased tariffs, have increased business growth by engendering competition [8]. The present telecommunications environment, in which individual users have to make choices, has become complicated. In the past, there was only one local telephone network operator that subscribers chose whether or not to use in this country. Currently, many different operators offer myriads of service options and packages. Telecommunication is a strategically important resource for most modern corporations and has an essential impact on the development of any community. The economic development of developing countries depends, among other things, on the availability of efficient telecommunications services [2].

Having to operate in a fast-growing and stiffly competitive market, telecommunication service operators must seek cost-effective ways to improve the coverage and performance of their networks. These may be in the form of equipment upgrades or expansion. And where the need arises, then, new switching and transmission equipment may be grafted into the existing network. In grafting, obsolete equipment are discarded while the relevant ones are integrated with the latest technologies to improve efficiency [3]. As a result of advances in technology rapid changes are taking place in the telecommunication sector. These changes driven by regulatory policies have had a profound effect on telecommunications particularly in the areas of computerization and digitalization. And because of this new trend, many countries are rushing to modernize their telecommunications equipment in order to cope with the demands of the information age. Coming home, the deregulation policy of the federal government paved way for privatization, liberalization, and globalization which eventually resulted into fierce competition in the commercial market. The resultant effect is that the telecommunication is currently facing a big challenge of upgrading the network services and functions. With the development of Computer Technology and the application of Internet and Multimedia Communication Technology, the traditional Voice Services and Low speed Data Services are far from satisfying the present market demand. This paper, therefore, presents the process of grafting as it relates to the national PSTN-NITEL.

2. OVERVIEW OF COMMUNICATION NETWORKS

The basic purpose of a communications network is to transmit information in a given form from one user to another within the network [2]. These users of public networks, a telephone network for instance, are called subscribers. User information may take many different forms such as voice or data, and subscribers may use different modes to access the network such as fixed or cellular telephones. The block diagram of public switched telephone network (PSTN), which is a fixed network, is given in Figure 1. The diagram shows that a PSTN is basically comprised of exchange – switches with elements and circuits [1]

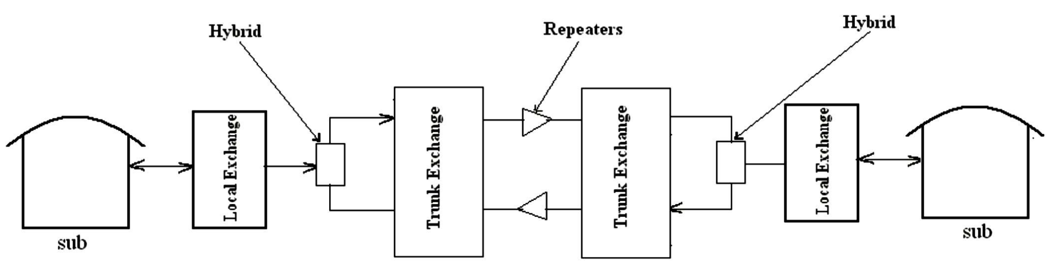

Figure 1: Block Diagram of PSTN

The three technologies needed for communication through the network are transmission, switching, and signaling. Transmission is the process of transporting information between end points of a network. Transmission systems use four basic media for information transfer from one point to another [2]

- Copper cables, such as those used in LANs and telephone subscriber lines;
- Optical fiber cables, such as high data-rate transmission in network backbones;
- Radio waves, such as cellular telephones and satellite transmission;
- Free-space optics, such as infrared remote controllers.

In a communications network, the transmission systems interconnect exchanges (switching centre). Together, these transmission systems are called the transmission or transport network. It is noteworthy that the number of speech channels needed between exchanges is much smaller than the number of subscribers because of economic reasons. A small fraction of the subscriber would need to be connected at the same time.

2.1 History and Trends of Switching Equipment

The various stages switching has under gone since 1878 towards the projected year 2020 is shown in figure 1.2. The next stage not fully utilized is optical switching. The target now is to use optical switching with electronic switch control to access information. Indeed, in view of the intensive research and development that is being carried out in this area, it should not be long before the first optical space switches are commercially available [3]. From the fore- going, one can appreciate the need for grafting having changed from one switching stage to the other. It would have been a waste of resources if after each stage; the equipment already would be abandoned. Upgrading is better than abandonment [wise].

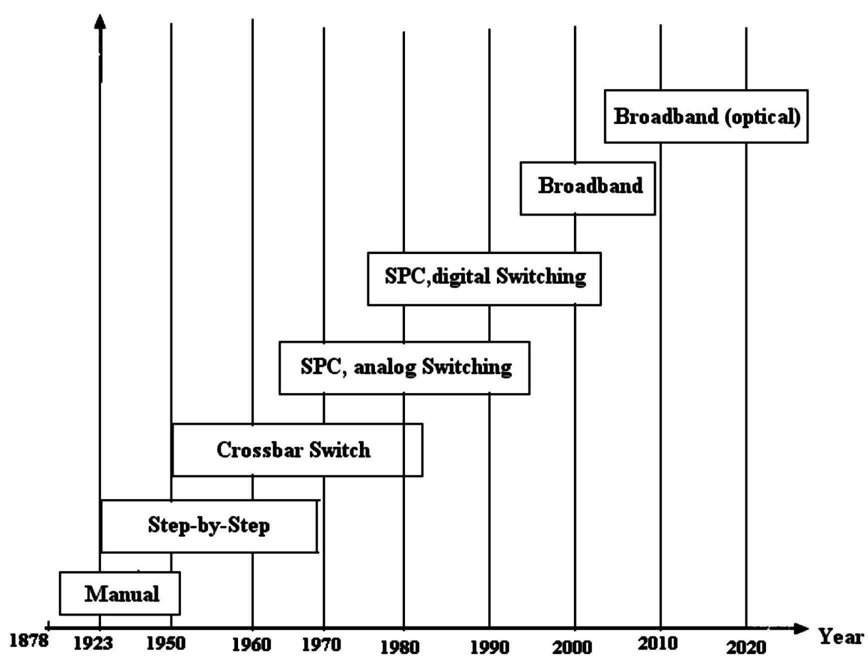

Figure 2: trend of equipment. History and switching

The first generation of switches was not automatic so switching was done manually using a switchboard. Strowger developed the first automatic switch exchange in 1887 see figure 2 [4]. At that time, switching had to be controlled by the telephone user with the help of pulses generated by a dial. For many decades exchanges were a complex series of electromechanical selectors, but during the last few decades they have evolved into software-controlled digital systems. Modern exchanges usually have quite a large capacity - tens of thousands of subscribers - and thousands of them may have calls ongoing at the same time.

Signaling is the mechanism that allows network entities (customer premises or network switches) to establish, maintain, and terminate sessions in a network [2]. Signaling messages are used to indicate to the network systems what is requested of them by a particular connection. Signaling is naturally needed between exchanges as well because most calls have to be connected via more than just one exchange. A standardized signaling system (SS7) is therefore used for the interconnection of different exchanges in the process of switching [1].

2.2 Switching and Transmission Equipment

Subscriber cables contain many pairs that are shielded with common aluminum foil and plastic shield [3]. In urban areas, cables are dug into the ground and may be very large, having hundreds of pairs. Distribution points that are installed in outdoor or indoor cabinets are needed to divide large cables into smaller ones and distribute subscriber pairs to houses. In suburban or country areas, overhead cables are often a more economical solution than underground cables.

An optical connection is used when a high transmission capacity (more than 2 Mbps) or very good transmission quality is required [3]. A microwave radio relay is often a more economical solution than optical fiber when there is a need to increase data capacity beyond the capacity of an existing cable network [3]. Installation of optical or copper cables takes more time because permissions from landowners and city authorities are required. Installation of cables is also very expensive when they must be sunk into the ground.

One technology for implementation of ordinary subscriber loops for fixed telephone service is known as *wireless local loop* (WLL) [7]. Wireless local loop uses radio waves and does not require installation of subscriber cables; it is a quick and low-cost way to connect a new subscriber to the public network. With the help of this technology, new operators can provide services in an area where another old operator owns the cables. Loop is also used for replacement of old fixed overhead subscriber telephone lines in rural areas [5].

When cable network capacity for subscriber connections needs to be increased, it may be more economical to install concentrators, remote subscriber units, or subscriber multiplexers so as to utilize existing cables more efficiently [5]. Concentrators may be capable to independently switch local calls among the subscribers connected to them. A remote subscriber unit is basically the subscriber interface part of the exchange that is moved away close to the subscribers. Subscriber multiplexers may only connect each subscriber a time slot (channel) in a PCM frame. Digital transmission between an exchange and a concentrator further improves cable utilization so that two cable pairs serve tens of subscribers [3].

Local Exchanges: Local or subscriber loops connect subscribers to local exchanges, which are the lowest-level exchanges in the switching hierarchy. Local Exchanges may be analog or digital. Digital exchanges however offer greater quality and reliability, and are thus preferred. The size of local exchanges varies from hundreds of subscribers up to tens of thousand subscribers or perhaps more. A small local exchange is sometimes known as a remote switching unit (RSU) and it performs the switching and concentration functions just as all local exchanges do [5]. A local exchange reduces the required transmission capacity (number of speech channels) typically by a factor of 10 or more; that is, the number of subscribers of the local exchange is 10 times higher than the number of trunk channels from the exchange for external calls. All subscriber lines are wired to the main distribution frame (MDF), which is located close to the local exchange. It is a large construction with a huge number of connectors. Subscriber pairs are connected to one side and pairs from the local exchange to the other. Between these connector fields there is enough space for free cross-connections. Cables and connectors are usually arranged in a logical way considering the subscriber cable network structure and switching arrangements. This fixed cabling stays the same over long periods of time, but connections between sides change daily, for example, because a subscriber moves to another house in the same switching area. A cross-connection in the MDF is usually done with twisted pairs that are able to carry data rates up to 2 Mbps. Ordinary subscriber pairs are used for analog telephone subscribers, analog and digital PBX/PABX connections, ISDN basic rate connections and ADSL [6]. Where PBX represents Public Branch Exchange, PABX represents Automatic Branch Exchange, ISDN represents Integrated Digital Network, and ADSL means Asymmetric Subscriber Line. ADSL and ordinary analog telephone circuits use the same 2-Wire subscriber loop. Data and speech connections may be used simultaneously and they are separated in the exchange where they are routed separately as shown in Figure 3.

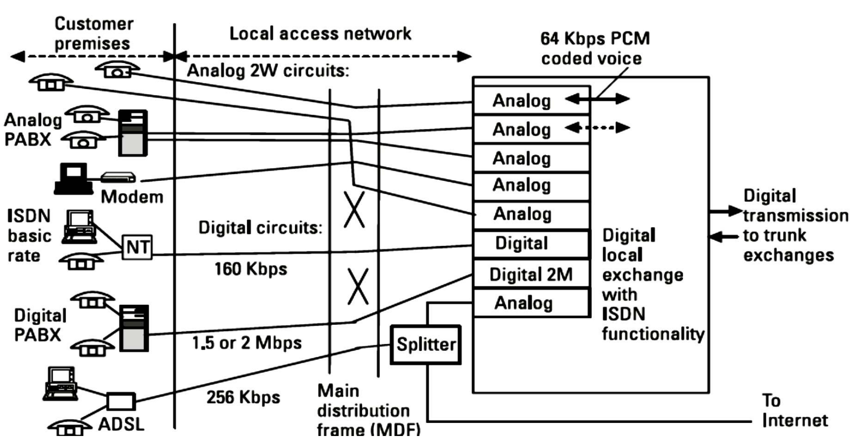

Figure 2.Local Network and Exchange Site Access Digital [10].

Trunk Network: Individual local exchanges are interconnected via trunk exchanges, which are linked to provide a network of connections from any customer to any other subscriber in the network. High-capacity transmission paths, usually optical line systems, with capacities up to 10Gbps, interconnect trunk exchanges. Note that a transport network has alternative routes. If one of these transmission systems fails, switches are able to route new calls via other transmission systems and trunk exchanges to bypass the failed system. Connections between local and trunk exchanges are usually not fault protected because their faults affect on a smaller number of subscribers. The transmission systems that interconnect trunk exchanges make up a transport network. Its basic purpose is simply to provide a required number of channels (or data transmission capacity) from one exchange site to another. Exchanges use these channels of the transport network for calls that they route from one exchange to another on subscriber demand. The trunk exchanges are usually located in major cities. They are mostly digitized and use the international common channel signaling standard SS7 to exchange routing and other signaling information between exchanges [1].

3.0 EQUIPMENT GRAFTING IN THE TELECOMMUNICATION INDUSTRY

The performance of any given network is dependent on the switching and transmission equipment that comprise it. Telecommunication equipment procurement and installation however cost huge amount of money. Whether in the form of expansion or upgrade, the grafting of new equipment unto an existing one is a popular business decision that operators are often faced with. Here in Nigeria, the case is not different especially with our PSTN-NITEL.

3.1 The Concept Behind Grafting

In grafting very obsolete equipment may be replaced with newer present while integrated with the latest technologies to improve efficiency. Grafting has succeeded in many areas of human activities. Several reasons may necessitate the grafting of switching and transmission equipment into an already existing network. However, they are all geared towards improved performance and increased market share. Such reasons may include:

- **Technical Upgrade:** This refers to the replacement of previously installed equipment with newer ones in order to take advantage of their superior features. A typical example may be the upgrading of a local exchange from analog to digital.
- **Traffic Congestion:** When there is an unprecedented explosion in the number of subscribers on a network, the available switching and transmission facilities may become inadequate to efficiently carry the traffic generated. In order to improve performance, the telecommunications operator would have to install more equipment with the latest technology.
- **Wider Coverage Area:** From a consumer perspective, one essential parameter that causes subscribers to prefer a certain network operator to another is the coverage offered. For this reason, operators often strive to extend their coverage area. This is particularly noticeable in the activities of GSM operators in Nigeria as they pursue the acquisition of wider coverage in a bid to achieve market dominance. The extension of coverage area may require network resource expansion and upgrade to latest versions.
- **Novel Technologies:** A given network operator may make a business

decision to roll out service packages in a new technology different from its already installed base. For instance, NITEL which has a large fixed network base has recently rolled out CDMA wireless services [4]. Such adoptions of novel technologies must be accompanied by the acquisition and installation of novel equipment which must be compatible with the existing network.

- **Interconnectivity with other Networks:** The deregulation of the telecommunication industry has engendered the participation of a variety of operators and investors. Therefore, a given geographical area may be covered by several parallel-running networks [1]. It is however required that subscribers on a particular network be able to reach those on another. Consequently, proper equipment may have to be installed to ensure compatibility.

3.2 Principles of Grafting

In the implementation and deployment of a high-speed wide area public digital network, the most challenging part is the link between the subscriber and the network. The network with billions of potential end points worldwide, the prospect of installing new cable for each new subscriber is daunting. Instead, network designers have sought ways of exploiting the installed base of twisted-pairs wire that linked virtually all residential and business customers to telephone networks. These links were installed to carry voice grade signals in a bandwidth from zero to 4 KHz. However, the wires are capable of transmitting signal over a far broader spectrum – 1MHz or more [5]. The solution here is grafting. Hence, one of the recent developments in the area of grafting is the introduction of Asymmetric Digital Subscriber Line which exploits the installed base of twisted – pair wires to enhance capacity in the network. The introduction of the technology has added new impetus on the demand for high – speed access to the Internet. Here, the user requires far higher capacity for downstream than for upstream transmission. Incidentally, ADSL uses frequency division multiplexing (FDM) in a novel way to exploit the 1 MHz capacity of twisted-pair. There are two basic elements of the ADSL strategy namely:

- Reserve lowest 25 KHz for voice, known as POTS (plain- old telephone service). Voice is carried only in the 0 to 4 KHz band; the additional bandwidth is to prevent crosstalk between the voice and data channels.
- Use either echo cancellation or FDM to allocate two bands, a smaller upstream band and a larger downstream band.

Note: Echo cancellation is a signal processing technique that allows transmission of digital signals in both directions on a single transmission line simultaneously [5]

3.2.1 Issues to Be Considered

Certain factors must be put into consideration when installing new switching and transmission equipment onto an already existing network. They include:

- **Compatibility Issues:** Compatibility usually presents the greatest challenge to equipment grafting efforts. The new equipment must be such that can be integrated seamlessly into the existing network. For instance, switching equipment manufactured by different vendors may not always be compatible. In fact, new products from a given vendor may not necessarily be backward compatible with older models.

- **Performance Index:** This simply refers to the extent to which the installation of the new equipment would improve the overall efficiency of the network. The benefits of the new installation must be juxtaposed with the current status quo to determine the feasibility of the grafting process.
- **Future Requirement Prognosis:** This entails a prognostic understudy of market trends to decipher an estimate of the future capacity requirements of the network. Thus switching and transmission equipment may be installed to avoid performance constraints in the near future. Prognosis is required to avoid duplicating efforts - a lump grafting process may be carried out at once instead of smaller spasmodic ones.
- **Deployment Cost:** This refers to the cost involved in carrying out the equipment grafting process. In some cases, a bank facility may be required to finance the process. In such a case, the Operator may be required to provide some collateral to facilitate the grants from the bank.
- **Expected Return on Investment (ROI):** In view of the rather large deployment cost encountered in the equipment grafting process, projections are often made to assess the expected ROI. The ROI figures go a long way in determining whether or not the grafting process is to be pursued or not.

3.3 Grafting Design Process

The grafting design process in PSTN is usually broken into two groups of activities namely: the designation of the local access transmission routes, and the determination of the digital switching and transport equipment that would be required for the proper functioning of the network [10]. The former is known as the outside-plant design while the later is called the central office design. Depending on the magnitude of the grafting process, the bulk design may be subdivided and sub-contracted to several firms. However, most operators prefer to outsource the entire contract to single turnkey total solution providers.

Outside-plant Design: This aspect of the project entails the selection of transmission routes between subscribers and the local exchange. Plans may be made for the placement of underground, aerial, submarine or wireless installations, depending on a number of factors including the terrain, existing infrastructure, environmental conditions, etc. The activities carried out in outside-plant design include:

- Route planning, identifying right-of-way requirements and potential design conflicts;
- Negotiating right-of-way agreements with landowners and/or spectrum control Commissions;
- Determining specialized design, plan, and digital mapping requirements such as Repeater locations, etc;
- Preparing preliminary designs, developing bill of quantities (BOQ) based on preliminary design and estimation tables, and providing as-built plans and specification.
- Completing final design and carrying out engineering change orders (ECOs) for variations that may show

up in the course of installation [6].

Central Office Design:
This aspect involves understanding what equipment must be installed for the network to function appropriately. The activities involved include:
- Determining what equipment must be added to the existing switching center;
- Determining the required digital equipment procurements such as time-division multiplexers, concentrators, remote switching units, frame distributors, etc;
- Reviewing the power system to determine whether or not reinforcements may be necessary;
- Developing the required software upgrades to control the underlying hardware;
- Developing bill of quantities (BOQ) for the required hardware and software [7].

The design process is followed by installation and commissioning. The commissioning process involves testing to make sure that the network is up to specification before it is turned on and integrated into the live network.

3.4 Design Layout for Grafting Process

Basically, one of the essences of upgrading or grafting is to make analog circuits to perform or work together with digital circuits for better efficiency [3]. It has earlier been stated that digital system is more reliable and efficient especially in the area of transmission. Upgrading is an act of bridging the gap between the old and the new equipment in order to make both compatible during operation [3]. In grafting there is the need to convert analog signal to digital, vice-versa to ensure proper signal transmission both ways. One of the primary reasons for converting the analog signal to digital is the ease with which it may be switched. The second reason is that there is almost no transmission noise introduced from one point in the system where the digitalization is done to the point where the signal is converted back into an analog signal [3]. Presently, many exchanges have been integrated into what is called Integrated Services Digital Network (ISDN)[9]. With the introduction of this technology, most subscriber lines are now digitalized. This is essentially what upgrading has done in the telephone systems. The illustration is given in figure 4.

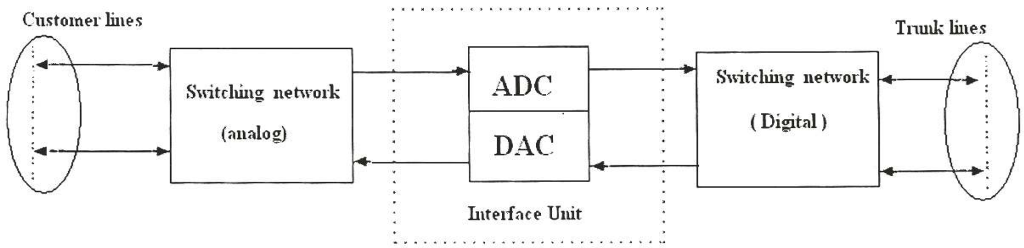

Figure 4. Design Layout

4.0 ON-GOING EQUIPMENT GRAFTING EFFORTS

For instance, the NITEL network covers the whole country with an extensive terrestrial network. It represents the PSTN (public switched telephone network). The critical issue is therefore the general expansion of the network – transmission, switching, and customer access, as well as international gateways. The company is currently pursuing an ambitious network expansion effort to boost its installed capacity to 8 million. The upgrading of our PSTN system, (NITEL), was made possible mainly by the introduction of Digital Electronic Switching System (EWSD) by Siemens. EWSD exchange allows the telephone network to evolve into an integrated services digital network (ISDN). The ISDN simultaneously handles the switching and transmission of telephone calls, data, text, and images reliably and economically in accordance with user needs. EWSD is designed to meet the up- to- date requirements in the telecommunication industries because of its features which is continuously being improved to satisfy future requirements as well as broadband services. New technologies can be incorporated or grafted in the EWSD without altering its system architecture. The access arrangement of an EWSD exchange for ISDN is available [9]. One major trend is the installation of optical fibre routes for trunk network connections in lieu of terrestrial microwave. Optic fiber operates at a much higher speed than terrestrial microwave and is often preferred for data traffic. Optical fiber obviates the high maintenance cost of microwaves and is not adversely affected by bad weather conditions. Interface equipment has also been installed for extension of the SAT3 cable network.

Furthermore, Integrated Services Digital Network (ISDN), an all-digital replacement for existing public telephone and analog telecommunication networks, is now being used by over 40 % of the subscriber base [9]. NITEL intends that all existing analogue local exchanges be eventually replaced by digital ones in the nearest future [9].

5. SUMMARY/CONCLUSION

The world is fast becoming a global village and a necessary tool for this process is communication of which telecommunication plays a pivotal role. The quantum development in the telecommunications industry all over the world is very rapid as one innovation replaces another in serried succession. Communication is undoubtedly a major driver of any economy. Emerging trends in socio-economic growth shows a high premium being placed on information and communication technology (ICT) by homes, organizations, and nations. Nigeria is not left out in the global quest for telecommunication services. The deregulation of the telecommunications industry, and other accompanying legislations, has ushered in immense market competition. As the number of subscribers increases, so also does the demand for quality service. Not wanting to lose their valuable customers, telecommunications operators strive to improve the performance of their networks through grafting.

The performance of any given network is dependent on the quality of the switching and transmission equipment that comprise it. Telecommunication equipment procurement and installation however cost huge amounts of money. Hence, network layouts are constrained to seek compromises between performance and cost. Whether in the form of expansion or upgrade, the grafting of new switching and telecommunication equipment onto an existing network is a popular business decision that operators are often faced with. The cycle thus goes – subscriber demand increases; network capacity must be commensurately increased; new equipment must be grafted into the network with so aim of enhancing performance and providing better services to the cherished customers.

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