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Merging Satellite Technology with Geographic Information System (GIS) to Improve Telecommunication Industry in Nigeria

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Abstract:
This research work uses the application of Geographic Information System (GIS) to present virtual effects of what exist on ground and what helps to explain why the GSM reception of GLO, MTN and other masts is poor in the study area. Secondly, what if scenarios were created in order to provide an alternative for site planning in installing transmitting gadgets to ensure maximum coverage in the study area. Obstruction was identified causing partial blockage, hence partial reception in the study area. Line of Site (LOS) or view shed analysis revealed that moving one of the transmitting masts westwards, will eliminate the poor reception of the study area. This paper also revealed the necessity for properly using GIS application in siting GSM mast. This paper is limited to the use of satellite technology and the geographic information system GIS in Nigeria communication satellite (NigcomsSAT-1) in enhancing the telecommunication industries in Nigeria.

Keywords: *Geographic information system (GIS), GSM, Line of Site (LOS) NigcomsSAT and satellite technology*

1. Introduction

Communication has become one of the integral parts of human beings particularly in this information age. From time immemorial, information and communication have formed the basis of human existence. People want to reach others and to be reached. This desire has been a driving force, motivating men to continuously seek for a new and effective means of dissemination of information to one another on real time basis irrespective of distance. The explosion in technology ushered in this desire with advent of the first-generation cellular telephone systems that enable people to communicate with one another irrespective of time and place. This first-generation cellular telephone system, which was analog system, was launched in 1960s before digital communication became prevalent (Goldsmith, 2005)

Before the advent of GSM in Nigeria, telephones were a luxury that a few privileged Nigerians enjoyed. However, with the advent of GSM in the last seven years, communications in the country had witnessed a tremendous boost. According to Hassan (2009), from less than 500,000 active fixed telephone lines as at middle of 2001, the total number of connected (fixed and mobile) telephone lines had increased to about 22.9 million as at March 2006. The figure has increased dramatically to 12 million by the end of 2007, with GSM or mobile lines accounted for about 91% of the total active telephones (fixed and mobile) lines (Ajiboye, 2007).

However, as the number of services and subscribers of GSM in Nigeria increases, the demand for good quality of service has become an issue in the country. The agitation has become a national issue which had been brought before the country House of Representative on July 18, 2007 and the Nigerian Communication Commission (NCC) (Adegoke, 2008). In finding the lasting solution to the problem, the NCC, body responsible for the regulation of GSM in Nigeria, on 6th July 2007 issue out the threshold levels on the key performance indicators (KPIs) for ascertaining quality of service of all the GSM networks in the country. The KPIs on which the GSM networks were tested according to Kollár (2008) include: call set-up success rates (CSSR), call drop rate (CDR), call completion success rates (CCSR), handover success rates (HSR) and traffic channel congestion rate (TCHR).

To any location, there are three (3) categories of GSM reception. The first category is area, which have full reception most of the time. The second category is area which experiences fluctuation in reception. Fluctuation are two types - rapid fluctuation (where changes in reception occur within seconds), and diurnal fluctuation (where reception exists in the night but vanishes completely during the day). Finally, the last category is those areas where reception is always absent. It is very likely that the GSM companies design the situation so. This is because some locations have highest cluster of subscribers, short distance coverage of the mast usually 3 to12 kilometers (2 to 7.5miles) and network jam (congestion) are predominant e.g. with the MTN_0803,0806, and 0705. The 0806, 0808, 0806, 0802, 0703, 0708, 0705 came because of network congestion. These are due to non-usage of the Geographic Information System (GIS) to effective atmospheric, weather, terrain analysis for setting GSM transmission gadgets. What then has the GSM done wrong? How can the wrong be rectified? These are some questions this paper wants to address.

The technology that results to incidence of poor network coverage is closely linked with Base station (BS) planning. The GSM uses services of radio transmitters known as base station to connect cell phone to GSM network. Each base station is termed as a cell, so named because it covers a certain range within a discrete area. Base stations are all interconnected, which is why one can move from one cell to the other without losing connection.

The biggest limitation to such technology is that cellular cannot provide global service for example; a base station cannot be placed or constructed in the middle of the ocean. By 1999, less than 20 percent of the world's land areas had cellular services. Desire for global wireless communication provided the impetus for new satellite technology communication.

The use of satellite technology and Geographic Information System (GIS) application in setting base stations is the answer to telecommunication industries in Nigeria.

This is used as a repeater station in the sky, and by the use of the GIS in the operation, the problem is overcome through the following:

- Propagation coverage for one or more transmitters draped over surfaces
- Interference and overlapping coverage
- 2-D and 3-1 visualization environments
- Fly through visualized capabilities

This concept, if adopted; will profoundly change the world today. Essentially a satellite acts as a radio relay in the sky. Signals such as voice, data, facsimile and video are sent to it from base stations antenna on earth; it then amplifies these signals and sends them back to other earth antenna base stations. The advantages of satellite communication include the following:

- Handle a large amount of traffic (bandwidth of 500MHz) which overcomes congestions.
- Receive\send signals over most of the population earth locations and regions,

Insensitive to distance (same cost), VIA orbiting satellite-uplink downlink with different frequencies. Frequency, range from 1-10GHz.

With regard to this paper, the major subject matter is the identification of the short coverage of the GSM network signal in Nigeria. The reason which is due to the existing technology adopted by the telecommunication companies, and the sage of two bandwidth identification for network code numbers 0803,0806, 0703, in case of MTN due to congestion of subscribers to the existing technology. Secondly, mounting of mast should be a thing of concern, by not casing our home or town to be like electric power transmission station without cables, and hence rendering it a wireless electric power transmission, signals which are sent as radioactive wave may be of negative effect to the human health.

The aim of this research work is to present a wider range performance of the telecommunication systems in Nigeria industries to the existing technology by merging or using satellite communication with Geographic Information System (GIS) based technology to give virtual image on the ground towards mounting of the telecommunication base stations. This will show a developed modelling - process by integrating Geographic Information system (GIS) and computer Aided Design (CAD) to visualize attributes in a GIS database to the construction of 3- dimensional objects and CAD system which when assembled together constitute simulated views of the visual landscape under consideration in which signal propagation may be due to the geographical landscaping.

The scope of this paper is limited to the use of satellite technology and the geographic information system (GIS) in Nigeria communication satellite (NigcomsSAT-1) in enhancing the telecommunication industries in Nigeria. However, analysis due to Geographic Information system and geo-spatial analysis to any giving TOPO can be a great help.

The satellite (NigcomsSAT-1) payload offers will go beyond services such as the C-band, KU-band, and L-band but the use of terrain analysis software on either laptop or desktop by the use of integrated land and water information system ILWIS GIS package and a digital elevation model of a particular area location TOPO is created (Figure 1).

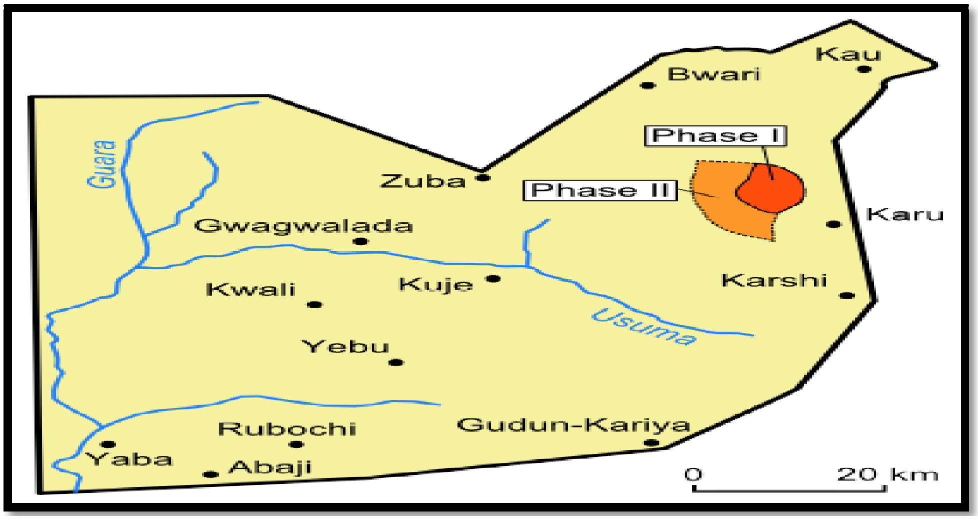

Figure 1: Satellite Communication TOPO Sheet

2. Review of Related Literature

According to Kazuto (2015), ICT is indispensable for economic, social and cultural development; free and open communication has come to be expected anytime, anywhere and on any device. However, there is a global digital divide, and in many countries telephone penetration (teledensity) is very low. Even in countries with higher rates of penetration and high-speed broadband networks, users often experience delays as a result of internet traffic congestion. This situation will only get worse as the appetite for content – particularly bandwidth-hungry videos – grows. Although we might not be able to see them down here on earth, satellites are all around us. This makes them the ideal solution to the problem outlined above. Satellites can be used alongside WiFi and other terrestrial solutions to deliver high-quality, media-rich content to users no matter where they live, and so ease internet congestion too. Their ubiquitous nature also means they can help bridge the digital divide by connecting people everywhere to broadband internet, ensuring nobody is left behind as we move into the digital era.

Communications satellites make up the bulk of satellites in orbit, providing television broadcasting, internet services and telephony. They have underpinned the information revolution, enabling long-distance communications in areas where terrain, distance or poor infrastructure make it too difficult to lay cables. The many benefits range from improved banking services to distance education and telemedicine in remote areas. Communications satellites are also bridging the digital divide between developed and developing nations by bringing internet services to remote areas (Kazuto S. 2015).

According to Kinley (2004), Since a user is not far from a base station, phone does not have to be made smaller. In addition, because areas are dividing into many cells, two subscribers in different locations can use the same channel at the same time. Cellular network must be able to pass calls from one cell to another as a user moves through an area. In the GSM era, the GSM uses services of radio transmitter known as base station to convert cell phone to the GSM network. Moreover, there have been records and instances of poor reception of signal due to mounting of base station and some terrain related barriers, which was analyzed by some authors. The problem of the short distance coverage was solved using the geospatial analysis, which had been conducted.

According to Goran and Finney (1991), US military constructed an 87ft radar tower of fort Lewis, Washington for communicating with aircrafts during aviation training. About 500ft radius of trees had to be cleared around for the tower to afford space for radar transmission. However, it was later discovered that obstruction from trees still posed a problem and additional 1000ft radius making a total of I500ft radius still needed to be cleared. Using Geographic information system GIS line-of-sight ability maps showing areas visible from an observer's locale were produced. Result showed that trees and hills at any cardinal post of a radar tower could easily interfere with radar transmission even after I500ft radius clearance. The analysis also showed adding 50ft to towers height would allow the needed clearance without any need to clear 1000ft radius trees.

According to Hall and Thomas (1994), how an integration of GIS and CAD can be used to visualize landscape changes. The main goal of this project is to develop a modeling process whereby features and their attributes in a GIS database are used to construct 3D object in a CAD system which when assembled together constitute views of the visual landscape under consideration. Results showed that the implication is most appropriate for visualizing regional land scape change, rather than specific land parcels. When compared, photographs, vegetable, data were found to contain the most inaccuracies. Other applications include ranges land planning and management - where the slope of training site was identified before military training (Dikks and Finney, 1994).

Landscaping prediction where water shed analysis was conducted on the digital terrain model, a soil strength map and a land use map were generated and overlaid digitally to produce the flood risk map (Balogun and Okunduwa, 2000). About 15,500 years ago, on the walls of caves near Lascaux, France, CroMagnon hunters drew pictures of the animals they hunted. Associated with the animal drawings were track lines and tallies thought to depict migration routes while simplistic in comparison to modern technologies, these early records mimic the two–element structure of modem GIS (an image associated with attribute information).

In the past two or three decades our capacity to survey and map the global environment has seen a "makeover" through the use of Geographic Information Systems (GIS), Remote Sensing (RS) and Global Positioning System (GPS). While GIS application enables the storage, management and analysis of large quantities of spatially distributed data which are associated with their respective geographic features; Remote Sensing is used to gather information about the surface of the earth from a distant platform, usually a satellite or airborne sensor. The two merges when the remotely sensed data used for mapping and spatial analysis is collected as reflected electromagnetic radiation, which is processed into a digital image that can be overlaid with other spatial GIS data of the same geographic site. With their continuous technological development and improvement, Remote Sensing information is increasingly being utilized in undertaking socio-economic developments and technological uplifting of the country, in the federal ministries and provincial departments, public sector organizations, international agencies and private sectors (Nandeche and Obindah, 2014).

As mentioned earlier, the current trend is towards the integration of different geospatial technologies. There is hardly any recent geospatial application that does not have components from two or more domains of geospatial technology. The idea of integration started with the use of remote sensing data in GIS and data from GIS serving as ancillary data in satellite image classification. In recent times, the integration has included computer-aided design (CAD), GPS, survey data, internet, RFID, geosensor and telecommunication. Even concepts such as space syntax, cellular automata and agent-based modelling (ABM) have been integrated into geospatial technologies (Jiang & Claramunt, 2002; Beneson, 2006; Sullivan, 2010). Likewise, software vendors have started integrating GIS, GPS and remote sensing functionalities in their packages. The trend towards synergy has been driving emerging applications in geospatial technologies and this might probably continue into the future (Yusuf, 2012).

The paper examines the nature of census operations in Nigeria and identifies the contribution of satellite remote sensing (SRS) data and geographic information system (GIS) to the contingency planning, mapping and management of census (attributes) datasets in Nigeria. Enumeration Areas (EAs) of a site in Enugu, Nigeria was mapped. The census datasets were modeled are presented as an ideal process. This was implemented using (IKONOS-1 m) image data in carving out the area, to demonstrate that SRS and GIS are very useful tools in handling census datasets. Ground reference data for carved-out area was collected using GPS handsets. A census database was created with various attributes, exploring certain aspects of data planning and processes. This was in terms of image (data)

Compatibility, modeling, and capacity for interactiveness of database management system (DBMS) network for spatial (query) analysis (based on user specified needs) was performed to determine the age, type or purpose of buildings and other facilities within the mapped EAs. The scale of the challenges faced by census managers; the no spatial credibility, crude data processing technique, socio-political tendencies, un-proportional houses, correlation, and attribute verification often results to contention, rejection and delay of census results in some cases. The paper concludes by suggesting new ways and means through which the Nigerian state through its agencies in census operations should explore to tackle this menace and save the nation from the embarrassments of poor handling of census datasets.

Telecommunications companies have begun to recognize that many of their work practices have spatial elements and data can be used more efficiently if shared between all departments. In the past, operators recorded information on the locations, compositions, capacities, and conditions of network equipment on a variety of maps, diagrams, and reports. These were often dispersed throughout the company and, if engineers needed to access data about any part of the network, they would first have to find the relevant papers and then interpret the records of previous workers. Often, the details would be inaccurate, or even obsolete, and users would have to make costly field inspections before beginning work (Barata, 1996).
Applications of GIS include activities such as planning transmission capacities, locating cellular telephone transmitters, recording customer complaints, and using geodemographic information to find new customers. Users would have to make costly field inspections before beginning work (Omogunloye and Qaadri, 2013).

This paper concentrates only on network monitoring and problem detection in an Ericsson equipment-based network. Monitoring in an Ericsson GSM Network is done at cell, Base Switching Center (BSC) and Mobile Switching Center (MSC) levels to have both a local and global view of the network. Different events are counted and collected by a subsystem called the Statistics and Traffic measurement Subsystem (STS). In the BSC, these events can be handovers, call setups, dropped calls, allocation of different channels, etc. There are also a number of status counters, reporting the status of equipment within the network, such as the current number of occupied channels. By continuously supervising the results from STS, the operator can obtain a very good overview of the radio network performance, which can help detect problems early (Ireti, 2005).

3. Method and Data

Line of sight (LOS) analysis which is also known as view shed analysis is the type of analysis that allows an analyst to know the area that is in view from one or more viewports. Applications of view shed analysis are numerous. Military application could include the location of sites best for military outposts. In law - keeping, the police could use it for locating areas suitable for monitoring crime or monitoring traffic flows. Television stations could use it to detect suitable areas for locating transmitting mast etc. (Figure 2).

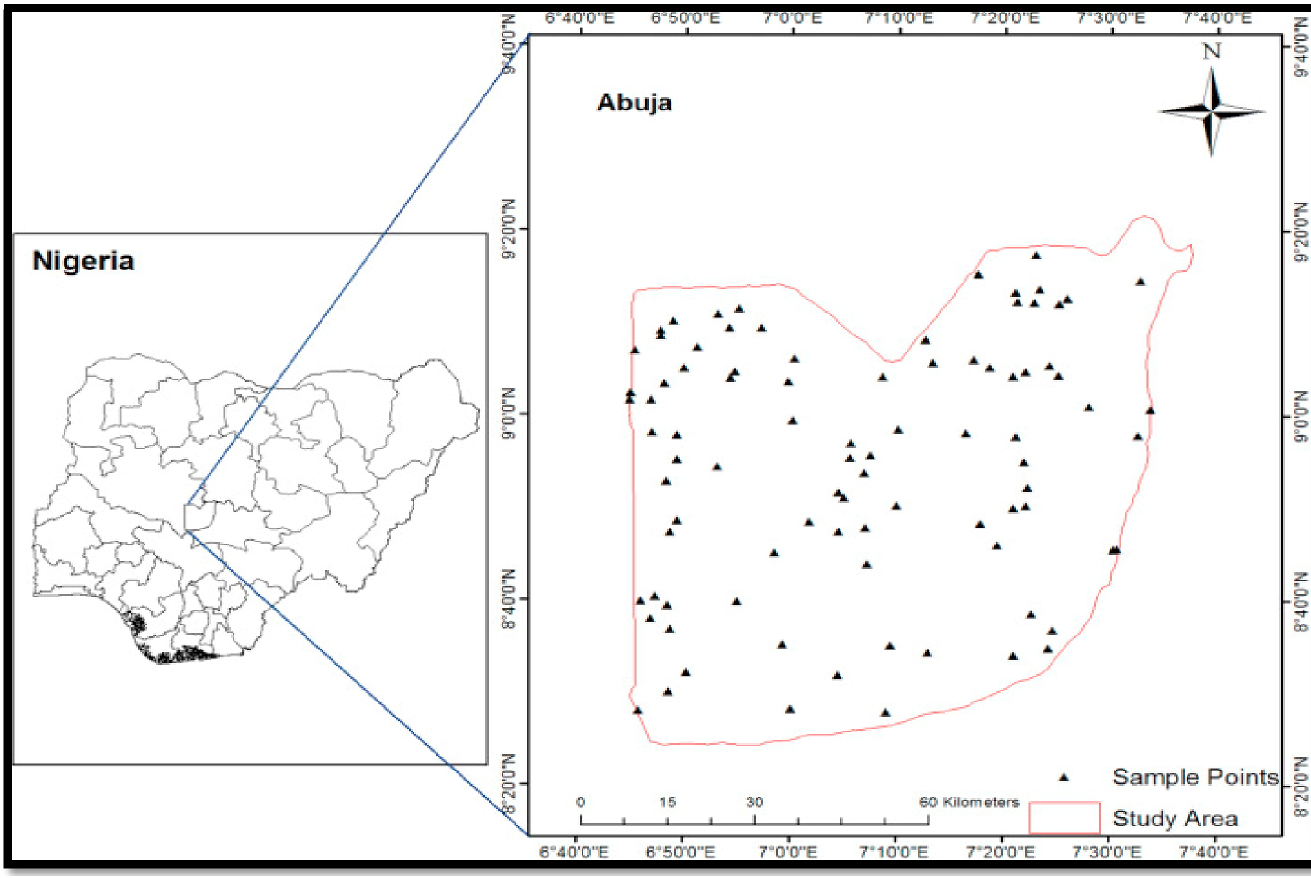

Figure 2: Satellite Communication TOPO Sheet Study Area

Four view ports (ports in which the satellite can be viewed via Nigcommsat) were used in this study. Since each view port represents a GSM transmitting mast, this implies that the result of the analysis indicates areas that receive signals (in view) and those that do not receive signals (not in view) from the transmitting masts. The analysis was done in two segments. Firstly, the analysis was carried out to identify areas in view shed on the present location of the transmitting mast and secondly, to acquire better location. The four viewports represent four transmitting masts in the city of Abuja Nigeria. One is at the Central Area at coordinate 220984N with 41M to 53M high.

The second mast covers Lugbe, Kwali and Gwagwalada. The one in Central Area (National Assembly, Ministers' suite, Asso Villa, police and judiciary headquarters, Eagle Square etc. Area 1, 2, 3,7,8,10,11 and Wuse i. and ii. The third viewport is at Gwarinppa at coordinate 218732N with 48M high which covers Gwarinppa, Kubwa, Bwari, Kuje, and Abuchi. While the fourth viewport is at NyaNya at coordinate 102551E with 50M high in order to cover Karu, Nyanya, Mararaba and Massaka (Figure 1).

4. Analysis and Result

From the analysis carried out, it is evident that a large part of the Gwarinppa view shed receives signals from Lugbe transmitting mast. The 3-imensional view of satellite image of the study area gives a clue that the sheds can be beamed to the orbit through the Nigeria communication satellite (NIGCOMMSAT) (Figure 3).

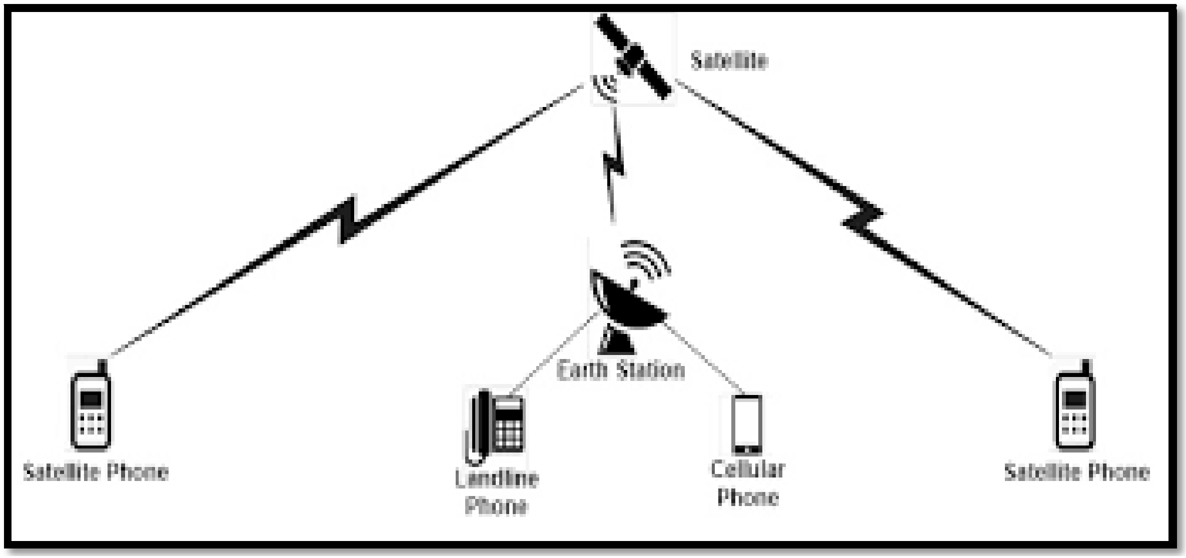

Figure 3: Satellite Communication

The Geographic information System are used together with the satellite image by receiving different signals from various view sheds to achieve the services such as place and direction of the caller and receiver including the multi-media services (MMS's) (Figure2).

5. Conclusion

More bandwidth is provided using satellite communication advances in the developed technology. Wave obstruction interruption caused by objects such as trees, hilltop view, desert, landscape and other terrain analysis is then overcome also, the knowledge of geo-spatial analysis is applied by avoiding mounting of mast, a secure and proper location to site it, is provided.

Finally, with the application of satellite technology, wireless networks whether ground-based or in space, would be able to handle all sorts of applications including video, voice and data and almost all networks would become interconnected.

In conclusion, the user selects the type of coverage and the propagation model to be used in the analysis. Figure 2, shows a composite analysis of the coverage of MTN, GLO, ZAIN, ZOOM and 9MOBILE transmitters located throughout the study area. The analysis is limited to sectors and specified distances around each transmitter to speed up calculations and focus on an area of interest.

However, the recommended locations for the new transmitting mast should be implemented by the network operators to ensure sufficient signals and complete multimedia services for the subscribers. The 3-Dimensional views of the satellite image of the study are to be merged with the views shed analysis of the recommended locations to display place and direction of the caller and receiver.

This paper will be of great benefit to the telecommunication industries in Nigeria.

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