MOBILE CELLULAR NETWORK INFRASTRUCTURE SHARING MODELS AMONG GSM NETWORK OPERATORS: A TECHNICAL REVIEW

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ABSTRACT
The number of users of the Global System of Mobile Telecommunications (GSM) worldwide is growing at an exponential rate; with more than 118 million users in Nigeria alone. There is a continuous need to install GSM supporting infrastructure in other to effectively care for the increasing users in term of service delivering. A major infrastructure is the GSM Base Station containing the Base Transceiver Station (BTS). By projection Nigeria need more than 30,000 BTS by 2018 amidst challenges such as high Capital Expenditure (CAPEX), multiple regulations and taxation, etc. This paper reviews different types and forms of infrastructure sharing. Infrastructure sharing comprises of the following types: Passive Infrastructure Sharing (PIS), Active Infrastructure Sharing, etc. Identified hindrances to infrastructure sharing include: Use of Different Supplier in value chains, use of Inferior Equipment, and monopolistic behaviour among well established operators. There should be a robust consultation among operators who intend to share infrastructure. The benefits of infrastructure sharing includes: increased revenue generation, achievement of competitive tariffs for customer, and more rapid network roll-out and market penetration. In addition, infrastructure sharing help mobile network operator to focus on their core business and customer services. When mobile operators share infrastructure the skyline is decongested.

Key words: GSM, Passive, Active, Infrastructure, BTS

I. INTRODUCTION
The number of users of the Global System of Mobile Telecommunications (GSM) in the world is growing at an exponential rate; with more than 118 million users in Nigeria alone (Nigerian Communications Commission, 2013). There is a continuous need to install GSM supporting infrastructure in other to effectively care for the increasing users in term of service delivering. A major infrastructure is the GSM Base Station containing the Base Transceiver Station (BTS). As at September 2013, the numbers of Base Transceiver Station (BTS) was 27,000. By projection Nigeria need additional 33,000 BTS by 2018 (ThisDay Newspaper, 2013). The roll-out of mobile networks requires high sunk investments and the need to recover those by charging the user heavily for accessing mobile services (Ericsson AB). This often makes mobile services less affordable and may discourage operators to innovate and migrate to new technologies in emerging markets. It may also cause licensed mobile network operators to obstruct the entry of new operators in the market and additionally, it may be too costly for new entrant operators to rollout mobile networks in rural and less populated areas, resulting in exclusion of a part of the population or certain regions from access to mobile telecommunication services (TIA Europe, 2001).

Conventional mobile network operation scheme is marked by vertical integration where the mobile network operator purchases and build the sites needed for rolling out the network, design the network architecture, operates, controls and maintains the network and customer services relationships, gain market share and provides services to customer-individual and corporate. While, technology migration, such as the launching of third generation (3G) and 3.5G wireless technologies on top of 2G networks, and the introduction of 4G technologies including LTE, is becoming increasingly rapid and complex (Informa Telecom & Media, 2010). Regulatory requirements also mandate coverage of areas that is not attractive from a business perspective. With growing competitive intensity and rapid price declines, mobile operators are facing increased margin pressure and the need to systematically improve their cost position.
In current market environment, focusing merely on the provisioning of coverage and capacity has a relatively low success factor, and to address this reality, operators are adopting multiple strategies, with network sharing emerging as a more radical mechanism to substantially and sustainably improve network costs. Mobile infrastructure sharing in telecom is an important measure to reduce costs. It is useful in start up phase to build coverage quickly and in the longer term scenario to build more cost effective coverage, especially in rural and less populated or marginalized areas. In the emerging market context, both in urban and rural areas infrastructure sharing should be adopted as an imperative for sustained telecom growth. As of 2012 about 60% of mobile network towers were shared by two or more Mobile network operator in India and more tower spaces are required in order to meet the future its future needs just as in Nigeria (Kumar, 2012; ThisDay Newspaper, 2013).

Mobile infrastructure sharing may also stimulate the migration to new technologies and the deployment of mobile broadband, which is increasingly seen as a viable means of making broadband services accessible for a larger part of the world population (Lefevre, 2008). Mobile sharing may also enhance competition between mobile operators and service providers, at least where certain safeguards are used, without which concerns of anticompetitive behaviour could arise. Ultimately, mobile network sharing can play an important role in increasing access to information and communication technologies (ICTs), generating economic growth, improving quality of life and helping developing and developed countries to meet the objectives established by the World Summit on the Information Society (WSIS) and the Millennium Development Goals established by the United Nations (Hasban & Chaban, 2007).

The various mobile cellular infrastructure sharing models available are highlighted as follows [8]:
• Technological model
  o Active sharing
  o Passive sharing
  o Roaming based sharing
• Business model
  o Mutual service provisioning
  o Joint venture
  o Third party service provider
  o Unilateral service provisioning
• Geographic model
  o Full split
  o Common shared region
  o Unilateral shared region
  o Full sharing
  o Urban/rural
• Process model
  o Engineering planning and network design
  o Deployment and rollout sharing
  o Maintenance and operation sharing
CATEGORIES OF TELECOMMUNICATION INFRASTRUCTURE UNDER THE TECHNOLOGICAL MODEL

Different forms of infrastructure sharing are possible, ranging from basic unbundling and national roaming, to advance forms like collocation and spectrum sharing—an active infrastructure sharing. In the Middle East and North Africa regions, National roaming is used extensively in countries like Jordan, Morocco, Oman, Saudi Arabia and the United Arab Emirates. Other forms of sharing are developing, given the expected returns to incumbents and new entrants alike. While infrastructure sharing is the most cost-efficient design principle for any new roll-out in emerging markets and the best approach for technology migration and consolidation (Wymann, 2007), the cost savings potential from infrastructure. In this technical review a discussion is done on the technological model.

Here emphasis is laid on mobile infrastructure. GSM architecture consists of the following components:

- **Active infrastructure** which consist of the electronics such as microwave radio equipment, switches, antennas, transceivers for signal processing—both BTS and Gateways, fibre optic network and backbone, transmission and all other electronic systems and components of the mobile network.

- **Passive infrastructure** which comprises the non-electronic infrastructure including but not limited to towers, shelters, air conditioning equipment, generator set, battery banks, electrical supply, technical premises and Rest Room and pylons that account for about 60 percent of network roll-out cost (Onuizuike, 2009). See Table 1 below for the categorization.

### Table 1: Mobile Infrastructure Components (Onuizuike, 2009)

<table>
<thead>
<tr>
<th>Active Components</th>
<th>Passive Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base stations</td>
<td>Tower</td>
</tr>
<tr>
<td>Microwave Radio Equipment</td>
<td>Shelters</td>
</tr>
<tr>
<td>Switches</td>
<td>Electric Supply</td>
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<tr>
<td>Antennas</td>
<td>Rest Room</td>
</tr>
<tr>
<td>Transceivers</td>
<td>Ducts</td>
</tr>
<tr>
<td>Fibre Optic network</td>
<td>Cable right of way</td>
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</table>

INFRASTRUCTURE SHARING MODELS

In general two factors such as the country and domesticated regulations determine the choice of infrastructure sharing models. The following section briefly reviewed various options of Infrastructure Sharing Models.

A. **PASSIVE INFRASTRUCTURE SHARING OR (SITE SHARING)**

This is the sharing of the non-electronic infrastructure at the cell site. It is also known as site sharing and in this form of sharing, operators agree to share available infrastructure such as site space, buildings and easements, towers and masts, power supply and transmission equipment. This kind of sharing is suitable for densely populated areas with limited availability, expensive sites such as underground subway tunnels and rural areas with high transmission and power costs. The key challenges in this model are for incumbent operators to accept the opening of the infrastructure to other operators and for new operators to trust that incumbents will provide them with the appropriate access to prevent them from rolling out their network effectively. It can be difficult to enforce cooperation (Onuizuike, 2009). Operators have to determine the available space on tower, power supply, interference and antenna isolation requirement. (Kumar, 2012; Telecom Regulatory Authority of India (TRAI), 2008) Gave a case where six (6) mobile network operators
comprising of four (4) GSM and two (2) CDMA operators shared the passive resources of a single tower in India.

B. ACTIVE INFRASTRUCTURE SHARING OR (NETWORK SHARING)
Here the operators share electronic infrastructure such as sharing BSCs, and sharing common networks, both circuit-switched and packet-oriented domains. In this model, operators typically share the RBS, RNC, MSC/VLR, and the serving GPRS support node (SGSN). Each operator, however, has its own individual network that contains the independent subscriber databases (such as HLR, AUC, etc) services, subscriber billing and connections to external networks. Among active infrastructure that mobile cellular network can share include: Fibre optic backbones and international gateways. Examples of such fibre optic network include the Main one and Glo-1-a project of 9,800km length of high speed fibre optic cable from Bude, United Kingdom to Alpha Beach Lagos, Nigeria (Wikipedia, 2015). Active sharing needs a more robust and deliberate planning, and deployment of efforts to accommodate each participating operator’s capacity needs (Onuizuike, 2009).

National GLO-1 |F|C Backbone

Fig. 1: Source: (Song, 2013; NigerianMuse.com, 2012)

C. SPECTRUM SHARING OR (SPECTRUM TRADING)
This is a model that has developed in mature regulated environment and it involves an operator leasing part of its spectrum to another operator on commercial terms. Since spectrum is a scarce resource that is often underutilized by one operator in a given location, sharing proves to be a viable option for two or more operators (Onuizuike, 2009). Modulation technique used can go a long way in determining efficient usage of the spectrum.

D. MOBILE VIRTUAL NETWORK OPERATOR (MVNO)
MVNO typically have no network and spectrum rights of their own though some advanced MVNOs will build parts of their core network needs, they basically depend on infrastructure to get access to subscriber and offer services (Onuizuike, 2009).
A. NATIONAL ROAMING (OR GEOGRAPHICAL SPLITTING)
Mandatory national roaming is a form of infrastructure sharing that allows new operators, while their networks are still being deployed, to provide national service coverage by means of sharing incumbents’ networks in specific areas. While national roaming is generally introduced with a Sunset Clause, it could be made permanent in competitions by allowing new players to launch their services within shorter time frames (Onuizuike, 2009).

![Various fibre optic networks within Africa. Source: (wikipedia, 2015)](image)

**Fig. 2:** Various fibre optic networks within Africa. Source: (wikipedia, 2015)

E. LEASING BY TOWER COMPANIES
Some Tower Management Companies like Helios Tower Nigeria can build Tower and lease it to one or more network operators (Okonji, 2012).
GUIDELINES AND SPECIFICATIONS FOR INSTALLATION OF TOWERS IN NIGERIA

Here are some highlights of the specifications provided by NCC (Nigeria Communication Commission, 2009) guiding the installation of GSM towers in Nigeria:

- **Towers and Masts**:
  i. The predominant load on tower structures shall be wind load.
  ii. The height of free standing mast shall not exceed 150 metres.
  iii. Mast and towers may be installed on a property with the written consent of the owner of the property.
  iv. Mast and towers above 30 metres in height may only be installed with a clearance certificate issued by the Nigeria Airspace Management Authority (NAMA) and irrespective of the height no mast is to be installed within 15 kilometres of any airport without prior approval from NAMA.

The antenna of each mast or tower shall contain the following particulars:

- Date of erection
- Height
- Number of antenna
- Operating frequencies
- Location address
- Geographical Coordinates
- Name of operator and licensee
- Effective Isotropic Radiated Power
- A long book showing inspection dates and types of inspections and types of the inspector.
Shared Use of Towers and Mast:
(a) The design, construction and installation of tower over 25 metres, is done so as to accommodate a minimum of three service providers using same structure.
(b) Owners of Towers shall provide written certification to the commission that such towers are available for use by other telecommunications service providers on a reasonable cost and non-discriminatory basis and modalities and conditions for such shared usage.

GUIDELINES ON COLLOCATION AND INFRASTRUCTURE SHARING
Here is a review of the guidelines on collocation and infrastructure sharing as issued by Nigeria Communication Commission (NCC) (Nigerian Communication Commission, 2009). The commission encourages and promotes sharing of the following infrastructures:
(a) Rights of way
(b) Masts
(c) Poles
(d) Antenna mast and tower structures
(e) Ducts
(f) Trenches
(g) Space in buildings
(h) Electric power (Public or Private Source)

Upon request by interested person the commission can add to the list of infrastructure that can be shared.
The NCC does not encourage and promote the sharing of the following infrastructures:
(a) Complete network structures
(b) Switching centres
(c) Radio network controllers
(d) Base stations

We have the following types of collocation:
(a) Physical Collocation: Means Collocation where equipment is placed in a separate room within the premises of the interconnection providing operator and remains under the control of the interconnecting demand operator.
(b) Remote Collocation: Means collocation where the equipment of the interconnection demand operator is installed in a location near the premises of the interconnection providing operator and a transmission medium is used to realize the physical interconnection.
(c) Virtual Collocation: Means Collocation where equipment is placed in the equipment line-up of the interconnection providing operator and is maintained by that operator.

COLLOCATION PROCEDURE OR WORK FLOW
The information below is a typical workflow when collocation is considered by two or more Mobile cellular operators. Note, the BTS Site for Collocation is often seen as a separate project from their routine BTS rollout project and the processes involved are highlighted as follows (Onuizuike, 2009):
• The RF engineers of one party check through its network for site for possible collocation
• The RF Engineers of the collocation send a list of possible BTS sites for collocation to the location operator Seeking First Line of Approvals
• The location operator perform collocation feasibility study in order to determine the availability
of resources such as tower space, floor space, power source and capacity, tower wind loading analysis, etc.

- The locator grants collocation approval for site sharing on identified BTS site
- Both parties (Locator and collocutor) Schedule Technical Site Survey (TSS) involving BTS Site to determine the actual scope of work to be done to ensure that infrastructures is properly shared with locator. The result of this exercise would be a BTS layout Design that depicts the floor layout arrangement for BTS infrastructure of both collocating parties.
- The locator party performs additional civil engineering work at existing BTS site to accommodate the BTS equipment (RF and transmission) of the collocation party seeking to collocate with it. In other words the locations operator upgrades its existing facilities and infrastructure to accommodate the BTS equipment and such thing as power output of the generator, etc. are upgraded.
- The locating operator or the host operator gives site ready for installation notice to the collocator to commence BTS equipment installations.
- The collocating operator receives notification of site readiness and deploys resources.

**BENEFITS OF INFRASTRUCTURE SHARING**

The main argument in support of collocation and infrastructure sharing put forth by Nigerian Telecom regulator, NCC is that of improving quality of service rendered by telecoms operators as well as reducing expenditure (Nigerian Communication Commission, 2009). Others include revenues gotten from monetization of non-current assets, faster time to market for new entrants and thus the capability to focus on customer service and core business. NCC believes that with infrastructure sharing and collocation, operators can achieve competitive tariffs for customers, rollout in less profitable areas, and control excessive proliferation of towers and mast, which makes the skyline untidy especially for aircraft especially in urban/sub-urban areas while encouraging competition.

Infrastructure sharing can prevent the risk of deterioration of Telecom Company’s image as the customers will see them as being environmentally friendly (Telnet, 2009).

With passive infrastructure sharing, operators are expected to save close to 30 percent on CAPEX (Capital Expenditure) and OPEX (Operating Expenditure) when it comes to passive infrastructure management (mainly towers). Passive infrastructure sharing, frees up capital which can be invested in radio network expansion and distribution (Onuizuike, 2009; Hasban & Chaban, 2007). In some Telecom markets, incumbent operators could generate significant revenues from infrastructure sharing which in some cases can be more than 15 percent of operators (Telnet, 2009) total revenue.

Infrastructure sharing help operators to shift focus from Network Deployment to service-base innovation which eventually lead to better Commercial Service offering and a healthier Competition. It also helps in optimization of the use of Scarce National Resources such as right of way, steel, spectrum, etc.

Again it can lead to lesser potential emissions and radiation harmful for the public and environment.

**HINDERANCES TO INFRASTRUCTURE SHARING IN AFRICA**

The following below have been identified as major deterrents or factors that often discourage operators in Africa from sharing infrastructure with other operators.

Hence, we still see three or four mast crammed in the same 200 square metre area.

- Use of Different Supplier in Value Chains: Many operators often complain of incompatibility of equipment and systems employed by other operators as major deterrents to infrastructure sharing. This hinders interoperability which is the ability of systems or equipments. From both sides, to operate without problems of mismatched configurations. This is due to fact that many operators often employ different Suppliers or Vendors in their value chains as a source of competitive advantage (Onuizuike, 2009).
• Use of Inferior Equipment: Some operators deploy systems of inferior quality and so others that seem to have superior systems might not be willing to share with these in order to maintain their competitive advantage (Onuizuike, 2009).
• Monopolistic Behaviour among well established operators: Often new entrants into some telecoms market in Africa often complain of anti-competitive or unfair monopolistic attitudes adopted by dominant incumbent operator who would have established wide network coverage prior to the entry of new operators. Hence, these monopolistic players create coverage prior to the entry of new operators. Hence, these monopolistic players create coverage prior to the entry of new operators.

CONCLUSION
Since collocation is possible for up to six (6) GSM network operators; this reduces capital expenditure (CAPEX) of rolling out network by new operators, and the expansion of older network into less profitable areas and a further cut-down of operating expenditure (OPEX), regulators should put policies in place that is aimed at overcoming or minimize hindrances to collocation of GSM network operators in a cell site.
In order to increase revenue, to contribute to cleaner airspace, and reduce environment visual impact-which lead to agitations by environmental activists; GSM network operators should consider sharing infrastructure as first option when it comes to rolling out network rather than building their network from scratch. Sharing GSM infrastructure is a viable option especially when regulation makes it difficult for GSM operators to obtain permission for new sites. There should be more focus on development of Nation Wide Fibre Network in order to promote broadband availability, not excluding economically non-viable areas. Encouragement should be given to active infrastructure sharing so as to permit mobile network to share resources such as spectrum, etc.

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