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Full Length Research Paper

Optimization models for minimizing congestion in Global System for Mobile Communications (GSM) in Nigeria

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Global system for mobile communications (GSM) is a digital cellular radio network that uses more advanced technology and handles more subscribers than the analog cellular network due to the use of Time Division Multiple Access to divide the channel in time. It offers high quality voice communication and low bandwidth (96 kb/sec) data connections for fax and Short Message Service (SMS). Data connection services like browsing, multimedia and e-mail demands on mobile telephone have increased tremendously. Many people have subscribed to GSM services due to the outlined features and all these have led to congestion on the GSM network. This is the main problem facing the GSM operators in the quest to satisfy subscribers. This paper gives a brief history of cellular networks, factors that led to the congestion and an overview of the congestion and where they occur on the GSM network. Some optimization models that can be applied to minimize the congestion problem on the GSM network in Nigeria are presented. These models are: government and corporate organizations in partnership with GSM operators use of dynamic half rate decoder, national roaming agreement, regionalization and merging GSM networks.

Key words: Global system for mobile communications, operator, subscriber, channels, roaming, congestion.

INTRODUCTION

Global system for mobile communications (GSM) was introduced to solve the problem of capacity, high-level of interference, high power consumption, signaling, inefficient use of radio spectrum and so on, that were faced in the analog mobile system. It was embraced by everybody considering the advantages associated with GSM like increase in the number of simultaneous user, clarity of voice communication. The performance of GSM has been affected due to the demand for the advanced data services like e-mail, internet browsing, multimedia that are accommodated within the technology.

How can we maintain a good, secured, uninterruptible network for disaster response, military command, public heath, safety corps and law enforcement command with this congestion problem? How can the congestion be minimized for everyone to enjoy the use of mobile communication?

The best way to acquire more subscribers and keep them satisfied is to make the service as easy to use and as reliable as possible. The need to satisfy the subscribers of wireless services and keeping them is paramount to the GSM companies. Thus, the need to tackle the problem of congestion on the GSM network as this will both be to the advantage of operators and users.

FACTORS THAT FAVOUR THE ACCEPTANCE OF GSM IN NIGERIA

The GSM communication is widely accepted due to the following reasons:

1. Quality: It produces a sharp and clear sound quality. The noise and distortions are reduced and drop out calls are fewer than analog.
2. Security: Everything you send and say within the digital network is safe because of its authentication encryption key distribution that guarantees the privacy of the call and caller identification restrictions
3. Capacity: The digital network service allows more calls to be handled at a time than analog, thereby accommodate more users than analog systems.
4. Convenience: GSM battery charge life span is twice that of analog therefore more convenient to use than that

of analog and not as bulky as the analog mobile phone.
5. Data service: The data service like SMS fax, offered by GSM makes things easier for people.
6. The reduction in the tariff: No matter the distance within the country the service rate remains the same. This has really had an edge over the wired telephone that depends on the distance for service rate.
7. Roaming: GSM subscribers are able to use their mobile phones in a number of countries around the world where GSM network is in operation. The international roaming allows service access outside the home network coverage area. Therefore, when traveling abroad, you only need to know if your home country GSM operator has roaming agreement with any of the operators in that country you are visiting.
8. The low acquisition rate: In Nigeria the amount of money needed to acquire a GSM line and phone cannot be compared to the one you will use to have wired telephone before, so this has really attracted many subscribers.

WHAT IS CONGESTION?

Congestion is the unavailability of network to the subscriber at the time of making a call. It is the situation when the blocking occurs and no free path can be provided for an offered call (Syski, 1986). That is, when a subscriber cannot obtain a connection to the wanted subscriber immediately.

The ideal telephone system is a situation where it is possible for all subscribers to talk in pairs simultaneously like the one shown Figure 1. If one connecting device be allocated for a pair of subscribers, then the number required will be too high to be reasonable (Syski, 1986). Such an ideal system is impracticable because of its enormous size, very high cost and maintenance difficulties.

It is therefore necessary to reduce the number of connecting devices which means that the subscribers are confronted with the possibility that some of their calls may be unsuccessful. The reduction in number of connecting resources consequently leads to reduction in the number of conversation which can take place simultaneously.

CONGESTION ON GSM

On the network side, four elements are related to congestion or indicate that a call could not be completed as itemized by Kuboye (2006):

1. Traffic channels congestion (TCHC): Traffic channels (TCH) represent a voice channel and each call uses TCH. There are eight channels defined for each radio frequency carrier and most are used for traffic channels and some for control channels (Mehrotra, 1997). When there is no free voice channel (TCH), then, we have traffic channels congestion (TCHC).
2. Dedicated control channel congestion (DCHC): Stand-alone dedicated control channel (SDCCH) is to provide authentication to mobile station, location updating and assignments to voice channel (TCHs) during idle periods (Mehrotra, 1997). When making a call or responding to paging message for the allocation of an SDCCH for authentication, if there is no vacant SDCCH to use at that time, the call will be terminated. This failure is called the dedicated control channel congestion.
3. Common control channels congestion (CCCHC): Common control channel is a group of control channels that support the establishment and maintenance of communication links between the mobile stations and base stations (Harte et al., 1999). It consists of random access channel (RACH), paging channels (PCH) and access grant channel (AGCH). RACH is used to make request for network assignment, PCH is used to alert the mobile station of incoming call and AGCH is used to assign mobile station to a specific DCCH or SDCCH for onward communication. When any of these three control channels is congested, there cannot be any call establishment between the sender and receiver, then, we have CCCH congestion
4. Pulse code modulation congestion (PCMC): Pulse code modulation (PCM) or E1 is the link required to connect the base station (BS) and mobile-switching center (MSC) together. Each PCM can carry between 1 and 32 calls. When there is no free PCM to carry the call signals between the BS and MSC, then we have pulse code modulation congestion.

Other factors that could lead to congestion are:

1. Inadequate radio channels and infrastructure to support the vast number of subscribers on the network.
2. Redialing of subscribers when they experience blocking.
3. Too many users on the network.
4. Marketing strategies and pricing schemes also affect traffic behaviour since this would have increased the number of subscribers on the network
5. Use of the old equipment facilities instead of new ones.

OPTIMIZATION MODELS FOR MINIMIZING THE CONGESTION PROBLEMS ON THE GSM AND OTHER RELATED NETWORK IN NIGERIA

Government and corporate organizations in partnership with GSM operators

The cost of building a base station and its maintenance is very high. The operators have to buy the land, antennae, transmitters, generator and employ security personnel before a base station site can stand. Government can

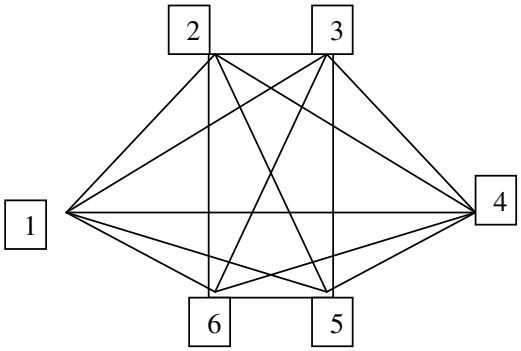

Figure 1. An ideal system.

come in so many ways to provide the following requirements:

1. Government can strengthen power holding company of Nigeria (PHCN) so that they can be having constant supply of electricity.
2. Government can supply security operatives like national defense and security corps officers to assist their own security.
3. Government can also invest in building the sites and lease them to the operators.

Corporate organizations can also help by taking up the areas that are heavily experiencing congestion but are not yet receiving the attention of the operators due to lack of money and do the following:

1. Buy lands and erect buildings for all the available operators.
2. Build and install the antennae.
3. Install a good generator for generating power.
4. Have a good security outfit.

When all these are put in place then they can now lease them to the operators. The rest are left for the operators to install their own branded facilities and this will lead to Site sharing or Co-location. This is a method practiced in most civilized country. This will prevent proliferation of masts all over the cities. If this model can be employed, it will do following:

1. It will remove the burden of building site.
2. It will remove the problem of maintaining the infrastructures and security.
3. There will be enough funds to install more radio channels.
4. It will allow the operators to quickly deploy GSM services through the nation.
5. Since the GSM operators can deploy enough radio channels, then the problem of congestion would be minimized.

As the time goes on and the number of subscribers had grown beyond the capacity of the present cell and there is need for cell expansion or division, the operators will only need to inform the organization that is providing them with the infrastructures for the need of expansion.

Dynamic half rate

Half rate is a process whereby only half of the normal data rate (full rate) is assigned to a user operating on a communication channel (typically a cellular). By reducing the data rate, the number of users that can share the radio communication channel can be increased. Creating half rate can double radio channel's capacity. GSM is designed so that it can easily accommodate a half rate speech coder (Harte et al., 1999).

In full rate, eight users or subscribers use a radio channel, but half rate decoder allows a radio channel to support 16 subscribers' conversations. Though, this model is not new but its use has been limited in practice. Most of the operators have favoured the use of full rate over the use of half rate.

Half rate speech coder produces speech at half of the present bit rate of the present full rate speech coder. Half rate speech coder compress a digital signal using advanced data compression techniques. The use of this higher data compression rates reduces the amount of data required per user and this increases the number of users that can share a radio channel (Harte et al., 1999). Considering the benefit to be gained by the operator (the subscribers number will doubled and improved network that will be enjoyed by the subscribers), a campaign should begin to let the operators and subscribers know this benefit so that they can go and buy half-rate enabled equipments.

National roaming agreement

Roaming is the capability to move from one wireless carrier's systems coverage area to another carrier's coverage area for service (Harte et al., 1999). That is, the capability of a subscriber from one wireless carrier such as MTN in Nigeria to be able to use another network like T-mobile network in US when such a subscriber is out of the coverage area of MTN.

Subscribers do not need to drop their phones or SIM while traveling, you can use your phone or your SIM wherever you are going, they only need to inform their operators in their home country about their traveling so that they be informed of the processes involved. For roaming to take place, the network operators involved must have an agreement with one another. This type of service is not presently available locally in Nigeria but the operators in Nigeria have such agreement with other operators in another country.

If this type of service is available locally in Nigeria, this

will allow the subscribers of different network to roam into one another network without any problem. What this means is that if subscriber A has MTN as GSM service provider and move to another location where MTN does not have any coverage, the subscriber can dial using Celtel network to process its calls. So the same thing applies to subscriber B that subscribes to Celtel, when in area where Celtel presence is not well felt, calls from subscriber B will use the MTN equipments and infrastructure for processing.

Regionalization

Presently, Nigeria is divided into six geo-political regions. In this model, the operators should not be given national coverage allocation; rather, they should be given regional coverage. One of the problems why we have congestion is the quest to cover the whole country when the capacity of their network cannot support such. The allocation can follow this zoning or a better zoning formula be worked out.

This will enhance the presence of the operator's network in that zone. If in the nearest future any operator want to seek approval for allocation in another region, there must be authentic prove that it has really established its network in the present region. Furthermore, there must be assurance that the level of service given will not be diminished and the same level of service will be rendered in the new region.

However, for this model to work optimally, the national roaming model must have been implemented to allow subscribers to make calls anywhere and everywhere within the country especially when they go out of the home network. The interconnection conditions revenue and other technicalities will be work-out by the two operators and national controlling body, the Nigerian Communication Commission (NCC). If this model is employed and practiced very well, there will be good and healthy network all over the country and congestion will be reduced drastically.

Merging two GSM networks

The driving force behind the merging of two GSM Networks is the expectation of a stronger market presence ad improved networks performance. The ultimate goal is to transform two separately existing networks into a simple homogenous structure that utilizes the existing assets (infrastructure) and applications to the maximum extent, simplify the operation of the network, and have improved networks performance.

The well-established service brands of both networks can be retained regard-less of any optimization of the underlying infrastructure (Walter and Robinson, 2004). Before embarking on the merging, the cost of a network merges versus the expected gains should be thoroughly analyzed to forestall future loss.

Benefits expected from merging networks

1. Low operating costs and higher earnings before interest, tax and depreciation. This will occur as a result of the fewer resources needed to operate the merged network and simple network architecture involved, with fewer sites to be maintained compared to when they are operated separately.
2. Immediate and sustainable capital expenditure savings because of the improved network economics and the removal of duplication. There would not be any overlapping radio coverage and separate transmission backbone because an improved site pattern would have been built reusing the existing sites facilities from both sites.
3. Capacity expansion and improved coverage area. There would be improved geographical coverage, that is, the coverage area of the merged network will be larger than each or at least one of the coverage areas. In overlapping areas, an improved cell-site will be built, re-using the existing sites facilities from both networks. This will provide increased radio capacity and improved signal strength to cope with greater subscriber density within the coverage area. The target network can use the spectrum from both existing networks, resulting in simpler frequency planning with reduced interference and an improved spectrum and increase in the subscribers.
4. Accessing variety of services and applications; since merging of these networks will allow most of their application environments to be combined. Subscribers to network A can now benefit from the applications of network B and vice versa.

Requirements specification for the merging

A thorough analysis of the merging requirements is needed in order to forestall future problems. The merging process has to be a gradual rather than immediate. The design of the new network depends on some requirements:

Branding

These elements are specific to a network and they are used to identify a subscriber with a network. Such elements are:

1. Service and application development; although GSM services are highly standardized, most operators offer additional propriety services and applications such as announcements and short codes for service centers such as voice mail.

2. Tariff scheme and payment method.
3. Numbering.
4. Operator identification that appears on the phone's screen upon network registration.

Regulatory requirements

The national regulator, Nigerian communication com-mission is saddled with the responsibility of allocating radio spectrum in Nigeria. This body will determine whether the total spectrum of both networks can be kept or not and the network IMSI number (the subscribers numbers) to be used.

Applications and services

The target network can in principle support all services and applications available on both networks, but the implementation depends on the branding or strategy. In terms of quality of service and coverage areas, GSM base stations from different vendors cannot be mixed within the same geographical area because of propriety nature of the Abis interface (Robinson and Walter, 2004), the interface between the Base Transceivers Station and Base Station Controller. Separation of the coverage area is needed where two mobile overlap especially with facilities from different vendors, base stations have to be dismantled and relocated to other areas. The desired network quality should be the force behind the design of the target network.

Conclusion

The performance of GSM networks is the most important issue concerning the operators, as this will keep the subscribers on the networks. In other to achieve the best performance, service providers have to monitor and optimize their network continuously. Therefore, the optimization models presented here will go a long way in helping the GSM operators to deliver a good and quality service to the subscribers.

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