

An optimized cellular network design using various technologies within a service area

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Abstract— this paper deals with Optimized Cellular Network with different access technologies with in the Staffordshire country. The main aim is to provide good coverage to the customers in the prescribed area as per the customers' utilization. For the cause of poor coverage probability and higher call blocking rates the network has been redefined. So the cellular network was designed with the target coverage probability of 0.98 and blocking probability of 1% which covers entire Staffordshire country. For designing practically we use a tool called "MENTUM PLANET" software providing capacity, coverage and frequency planning and analysis of Staffordshire County according to the customers' utilization.

Keywords— Global Systems for Mobile Communications, Universal Mobile Telecommunications Systems, Long Term Evolution, Core Network, UMTS Terrestrial Radio Access Network, Radio Network Controller, Frequency Division duplex..

1. INTRODUCTION

In present day technology, mobile world plays a high flying role in every individual day to day life. There has been drastic change in the field of cellular technology since few decades. Even today the network technologies are developing with new requirements depending upon the usage of traffic, but in early days it was utilized for minimum and limited requirements. Here we are designing optimized cellular network and obtaining network constraints and parameters.

While talking about the mobile communications, there has been tremendous improvement on different generations over the past few years. In the first generation, in early 80's Analogue systems came into existence and are called as NMT ("Nordic Mobile Telephone"). In the second generation GSM was developed and used EDGE ("Enhanced Data GSM Environment") technology which offers data rate up to 384Kbps. In the third generation, UMTS came into existence which uses WCDMA (Wideband Code-Division Multiple Access) and providing high data rates. In fourth generation, LTE ("Long-Term Evolution") has been developed which is the latest technology leading the entire mobile communications in today's competitive world.

2. BACKGROUND RESEARCH

As the document aim is to design Optimized network with different mobile technologies in particular area and provide less blocking rates, best handover and Quality of service. In order to meet the above conditions, background research should be done regarding Staffordshire County.

In terms of area and population the Staffordshire seems to be the largest county where the others do not meet with those requirements. It is located in the west midlands of UK.

- The total area of Staffordshire county is 2,716.19km²
- Total population is 1,096,700

The total 9 regions of this county is given below

- Tamworth
- Litchfield
- Cannock chase

- South Staffordshire
- Stafford
- Newcastle Under Lyme
- Staffordshire moorlands
- East Staffordshire
- Stoke on Trent



Fig. 2.1. Staffordshire County and its Districts

Here in our network design we are mainly concentrating on improvement of limitations of network especially on coverage probability. For designing a cellular network which is using UMTS technology providing the same coverage probability with a link budget of 144Kbps data rate, we considered the evaluation from GSM to UMTS later to LTE. The coverage planning was done by dividing the regions into different types followed by updating the link budget for UMTS to 144Kbps data rate. The required theoretical calculations are shown below.

2.1 GSM (2G) - Global Systems for Mobile Communications

GSM stands for Global System for Mobile Communication which is used for digital communication. GSM provides improved quality and flexibility over first generation mobile services and can able to allow mobile phones to make and receive calls when travelling. These offer advanced technical features that supports wide range of services including international roaming. It also includes short message texting, web browsing and picture messaging.

The wireless telegraphy act licenses for 2G cellular services were allocated through public consultation processes in the 1980s and 1990s.

The MS and BSS communicate across the UM interface, also known as the air interface or radio link. The BSS communicates with the network service switching center across the interface.

In GSM network the following areas are defined.

- **Cell:** Cell is the basic service area for which one BTS cover one cell. Each cell is given a Cell Global Identity (CGI) that uniquely identifies the cell
- **Location Area:** This is the area covers when the subscriber gets an incoming call. Each location area is assigned a Location Area Identity (LAI). Each location area is served by one or more BSCs
- **MSC/VLR Service Area:** It is defined as the area covered by one MSC is called MSC/VLR service area.
- **PLMN:** The area covered by one network operator is called PLMN. It contain one or more MSCs.

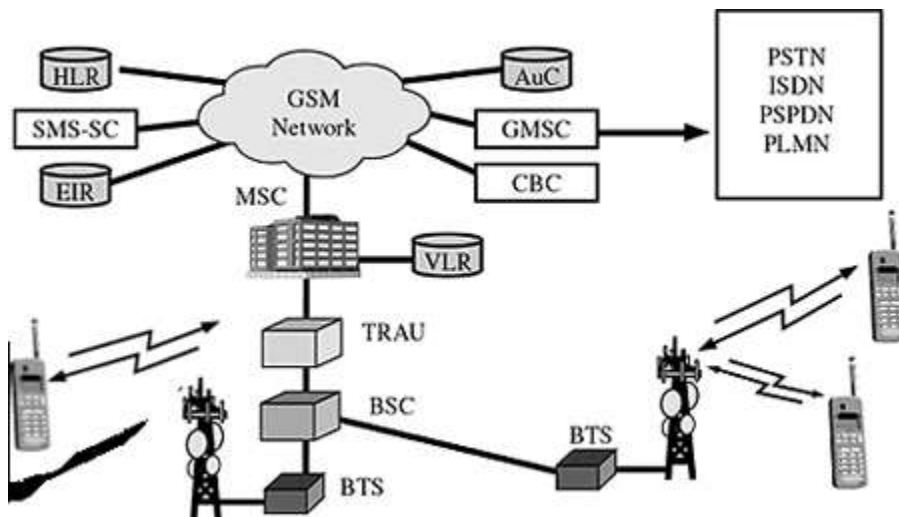


Fig. 2.1.1.GSM Network

2.2 UMTS (3G)-Universal Mobile Telecommunications Systems

UMTS means "Universal Mobile Tele Communication System" which is the third generation digital mobile technology. The UMTS network consist of three interfacing domains called Core Network(CN), UMTS Terrestrial Radio Access Network (UTRAN) and User Equipment (UE). The main function of the network is to provide switching, routing and transit for user traffic. Core network also contains the databases and network management functions.

The basic Core Network architecture for UMTS is based on GSM network with GPRS. It modified for UMTS operation and services. The UTRAN provides air interface access method for User Equipment Base Station referred as Node-B and control equipment for Node-B's is called Radio Network Controller (RNC). It is necessary for a network to know the approximate location in order to be able to page user equipment. The list of system areas is shown.

- UMTS systems
- Public Land Mobile Network(PLMN)
- MSC/VLR or SGSN
- Location Area
- Routing Area
- UTRAN Registration Area
- Cell
- Sub cell

UMTS also have Virtual Home Environment (VHE). Both connections oriented and connectionless services exist for point to point and point to multipoint communication. Offered data rate targets are

- 144 Kbits/s satellite and rural outdoor
- 384kbits/s urban outdoor
- 2048kbits/s indoor and low range outdoor

Bearer services have different QOS parameters for maximum transfer delay, delay variation and bit error rate. UMTS also has improved network security and location services.

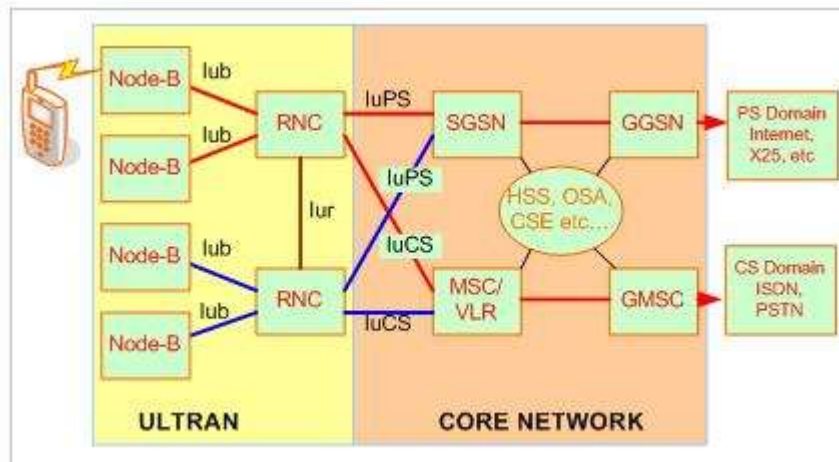


Fig.2.2.1. UMTS Network

2.3 LTE (4G) - Long Term Evolution

LTE means "Long Term Evolution" which is 4G technology came into existence and ruling the present day mobile communications but not yet become popular. This 4G LTE is being driven by combination of emerging wireless services. Few people in mobile industry dispute the inevitability of 4G Long Term Evolution but the timing and nature of deploying LTE network technology is less. In LTE uplink and downlink transmission paths are separated by using Frequency Division duplex (FDD). The operating of the system and its architecture is completely differ to that of UMTS.

In general the architecture of LTE is similar to GSM and UMTS. The entire architecture is divided into two parts.

- Radio network
- Core network

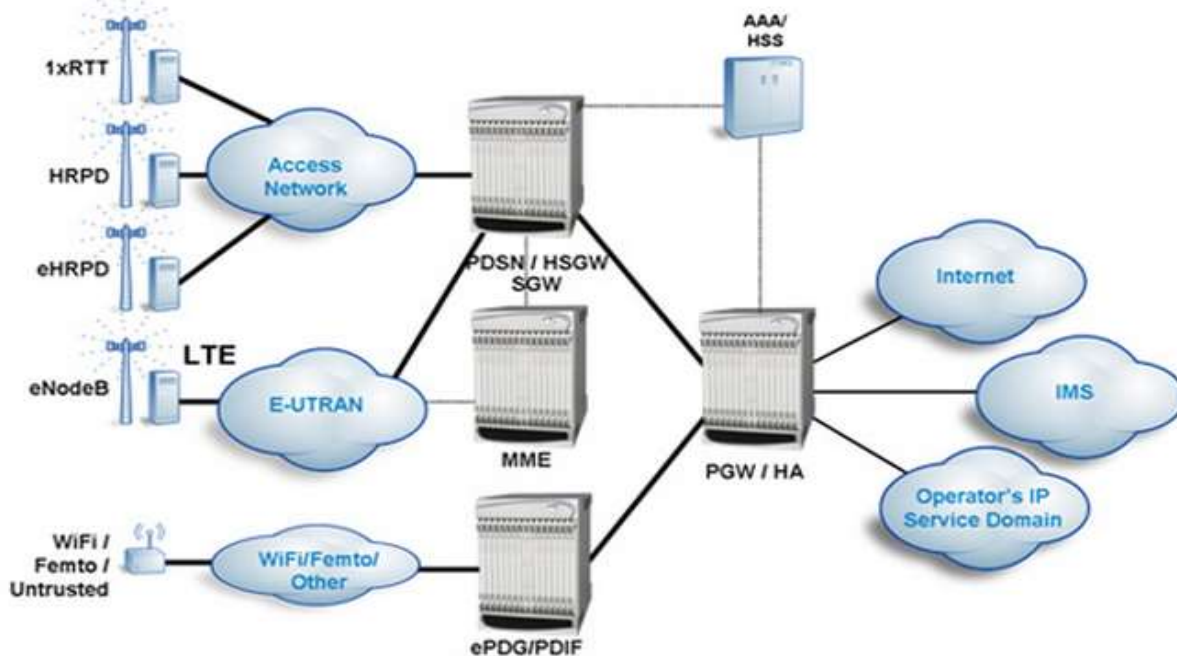


Fig.2.31. LTE Network Overview

These are employed in different frequency bands depending on the geographical location.

3. DESIGNING OF THE NETWORK

To design a network we need some basic components. In the process of mobile communication, every part has its own recognition. The base station serves as cell and diameter ranges up to few kilometers. CLUSTER can be defined as group of cells. Single cluster which consists of number of base stations is connected to MSC (Mobile Switching Centre) with the help of landlines. MSC can originate calls between the customers in that particular cluster when the calls demanded.

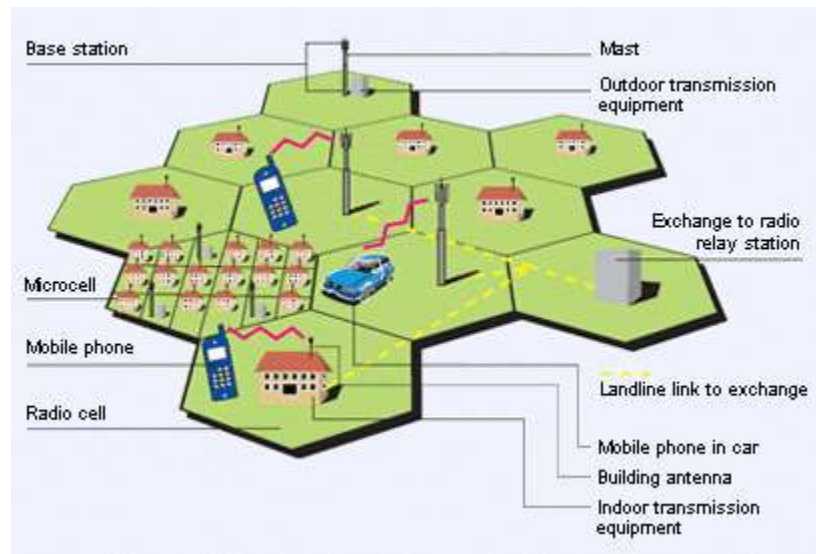


Fig.3.1. Basic cellular network

While utilizing the network it depends on the type of terrain in which the country has been located. It varies from rural and urban areas because in rural areas there is less number of subscribers in which urban areas has more number of subscribers. So while designing the network for Staffordshire county, it is required to develop some factors called capacity, coverage and less blocking rate. We have founded all the parameters for Staffordshire county initially and later for individual regions.

4. THEORETICAL CALCULATIONS

Here we have to consider the Staffordshire County for 9 different regions and their specifications are as follows:

I. Stoke-on-Trent:

- Area: 92.74 Km²
- Population: 2,39,700
- Latitude and Longitude: 53⁰ 00'' N / 2⁰ 11'' W

II. Tamworth:

- Area: 30.85 Km²
- Population: 76,000
- Latitude and Longitude: 52.633⁰ N / 1.695⁰ W

III Litchfield:

- Area: 330.3 Km²
- Population: 30,583
- Latitude and Longitude: 52.6835⁰ N / 1.865⁰ W

IV Cannock Chase:

- Area: 78.9 Km²
- Population: 94,700
- Latitude and Longitude: 52⁰ 43'' 50'' N / 1⁰ 58' 13'' W

V South Staffordshire:

- Area: 407.3 Km²
- Population: 1,06,600
- Latitude and Longitude: 52.6285⁰ N / 1⁰ W

VI Stafford:

- Area: 598.2 Km²
- Population: 126, 000
- Latitude and Longitude: 52⁰ 48'' 18.05'' N / 2⁰ 6' 59.99'' W

VII New Castle Underlyme:

- Area: 211.0 Km²
- Population: 124,500
- Latitude and Longitude: 53.011⁰ N / 2.229⁰ W

VIII Staffordshire Moorlands:

- Area: 575.9 Km²
- Population: 95,400
- Latitude and Longitude: 53⁰ 6' 23.75'' 50'' N / 2⁰ 1' 36.06'' W

IX East Staffordshire:

- Area: 390.0 Km²
- Population: 109,400
- Latitude and Longitude: 52.8080⁰ N / 1.6457⁰ W

Depending upon the density of population and existing demand of the customers the areas are divided in four different types. They are

- Type 1: Large city
- Type 2: Medium sized cities
- Type 3: Suburban
- Type 4: Open areas

5. MENTUM PLANET SOFTWARE

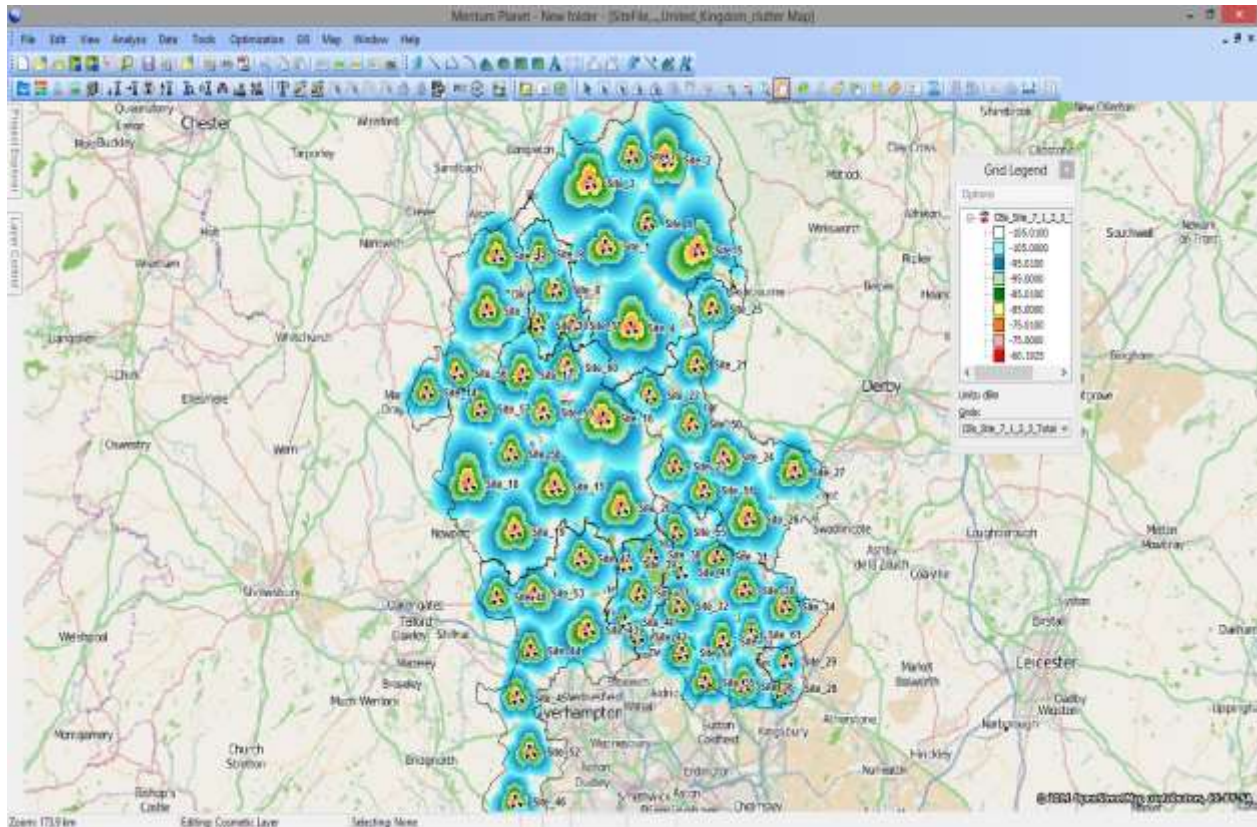
Mentum planet is software which is focused on wireless network planning and wireless design. It helps to design and optimize wireless access and transmission networks. It has advanced software including wireless technology educational services which enable operators to manage and optimize existing networks, coverage expansions. Wireless networks are continuously modified as the operator must adapt to the customer demand while modernizing, expanding and optimizing the network. In order to manage these changes the network planner needs a platform to deal with those scenarios. It is very cost effective, while we designing any network in real time scenario and if the network fail there is a lot of investment loss. So it is best preferable in such cases. It helps more than 250 customers in 90 countries by defining wireless networks. Mentum is a privately held company headquarters at Paris, with other offices in Dallas, Ottawa, Hong Kong and Tokyo.

6. SIMULATION USING MENTUM PLANET

In the simulation part, we can do by using the Mentum Planet software by which the background research was done theoretically or practically. Here the base station is to be located to meet the customer needs. The area and population can be calculated in theoretical way and the latitudes and longitudes for every region are known separately for obtaining

- Best Server Signal Strength
- Coverage Probability
- Required Mobile Power
- Total C/I ratio

7. Output Results: For entire Staffordshire County



CONCLUSION

Finally we have designed GSM network for Staffordshire County and provided 0.98% coverage probability and 1% blocking probability. Both theoretical and practical progress of designed network is shown. Now the designed network supports better data capabilities which well suits for coming generations having better services like uninterrupted call service and video streaming. The network which is designed is moved from GSM to UMTS and then extended to LTE. Thus the total practical approach is done by using Mentum software.

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