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Comparative Study between UMTS, HSDPA and HSUPA

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Abstract: *The purpose of this research is to effectively analyze the application of 3G especially in relation to the implementation of UMTS technology. An extensive examination of the UMTS architecture will be explained. The prime need of conducting an extensive research on this topic is to get an insight into the principle areas that enhance the speed and data rates of the organizational operations. The study will also incorporate a brief discussion of the HSDPA and HSUPA in the latter part of the paper for better demonstration of the efficacy offered by the 3G technology.*
Keywords: *UMTS; HSDPA; HSUPA.*

I. Introduction

The purpose of this paper is to critically examine the applications of 3G. The prime focus on this paper will be given on the effective and efficient UTMS technology. However, to understand the 3G technology in broader spectrum, HSDPA and HSUPA will be discussed in brief detail. For accomplishing the aforementioned aim, the assignment begins with the overview of the contemporary technology of UMTS along with a comprehensive description of the UMTS architecture. This will be effectively followed by a thorough analysis of the Core Network. In addition to this, a number of different elements of CN will also be defined in the paper. These include MSC, VLR and GMSC. After this, various elements of the packet switched domain will be incorporated, which include SGSN and GGSN. In the end of this section, the advantages and disadvantages that are related to the UMTS technique will also be discussed. In the latter part of the assignment, the technologies of HSDPA and HSUPA will be addressed so that a comprehensive understanding about the 3G can be gained.

II. Problem Statement

It has been observed that there has been comparatively slower transfer of data and information between different networks, which is effectively reducing the effectiveness of a number of different operations. Therefore, there is a critical need that these slow data rates must be suitably addressed.

III. Proposed Solution

For the purpose of addressing the aforementioned problems, it is highly recommended that the systems and networks make use of the effective and efficient 3G technologies. Therefore, this paper will study the application of 3G with relation to the incorporation of UMTS technology.

IV. Methodology

For the conduction of research on the application of 3G technology in the organizations, a thorough primary data analysis has been carried out. The reason for the research is to get an insight into the implementation and importance of the implementation of 3G technologies. For this purpose, the computer engineers and architects of a number of different organizations in the region of US will be interviewed about the importance of the concept. The past studies of different authors will also be researched thoroughly for acquiring a better understanding of the relevant research areas. Some authentic libraries to be used for collecting secondary data for this research may include; Phoenix, JStor and EBSCOhost. And we have used ATOLL simulation to illustrate some of the differences.

V. Literature Review

A. Utms

Universal Mobile Telecommunications System (UTMS) is considered to be an effective and efficient 3G mobile communication system in which there is an incorporated radio interface system. Additionally, it has been observed that the radio interface system is significantly based on Wideband Code Division Multiple Access (WCDMA). The radio frequencies that have been used in this system are of the order of 1900-2025 MHz as well as 2110-2200 MHz. It may not be wrong to say that the system is considered to be among the top most 3G mobile systems (Al- khaldi, et.al, 2012). In this mobile system, a range of wireless multimedia communications is possible that are spread across the entire internet protocol. It has been observed that this

system allows a number of different mobile internet users for the purpose of enabling them to access a variety of multimedia contents. These contents are available across the entire internet and they are considered to be arranged in a seamless fashion with data rates that are as much as up to 2 Mbps inside and 384 Kbps outside (Anonymous, n.d.).

1) UMTS Architecture

It may not be wrong to say that the entire UMTS system effectively utilizes the most used and most common architecture that is incorporated by almost all primary 2G systems. A simplified structure of architecture is significantly composed of various elements that are related to the logical network. These compositions are based on the basis of well-defined functionalities. In addition to this, it has also been observed that UTMS effectively employs WCDMA as on if its main and principle standard for the purpose of carrying out tasks that are related to air interface (Anonymous, n.d.). Moreover, this concept is effectively defined to be standardized by the prominent 3rd Generation Partnership Project (3GPP). In addition to this, the network elements that are the components of the system are carefully grouped into UTMS Terrestrial Radio Access Network (UTRAN), the Core Network (CN) and the User Equipment (UE) (Bhalla & Bhalla, 2010).

The CN is defined as the one in which the switching and routing of the calls as well as data connection is done with the external and far-fetched networks. Furthermore, the UE is responsible for effectively interfacing the user applications with the radio interface. This is done so that a better transmission and communication between the objects is possible and the losses due to noise signals may be effectively removed. It has been observed that the UTRAN is significantly composed of a Node Bs which is observed to be connected to a suitable and error free Radio Network Controller (RNC) (Heiska, 2002). This connection is made via a productive Iub interface. Here, it is significant to understand that a comparatively more generic and commonly used term for a Node B is considered to be a base station. Additionally, CN, which is unambiguously and rightfully considered to be the backbone of the entire system of UMTS, aims to correctly encompass the Serving GPRS Support Node (SGSN). CN also works to encompass the Gateway GPRS Support Node (GGSN) also. Apart from this, UE is such a mobile station that is effectively linked to the Node B. This linkage or connection is made through the whole radio interface of UMTS (Laiho, et.al, 2007).

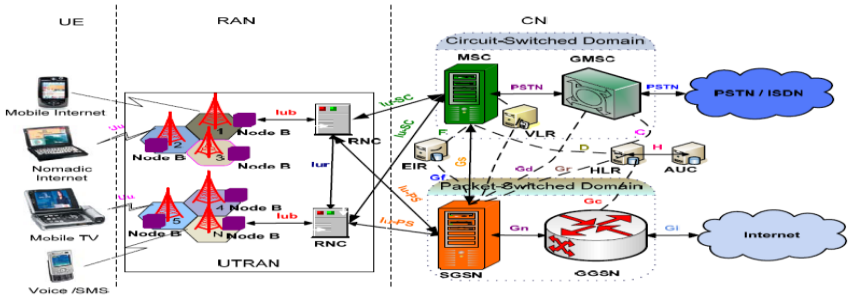

Fig.1 UMTS Architecture (Source: Google)

2) Core Network (CN)

To understand the concept of CN in absolute detail, it may not be wrong to say that the processes of the UTMS systems that are associated to CN are considered to be the primary reason behind the telecommunications system at large. These CN aims to provide absolute connections with the different devices in the system. One of the most common types of 3GNC is considered to be the one, which is based on the GSM network with the GPRS. In addition to this, the most important primary functions of the CN are related to the provision of switching, routing and transiting for effective user traffic. In addition to this, it has also been observed that the entire 3G network is divided into two main domains. These are defined as the two domains related to circuit switching and packet switching. The following lines aim to discuss the elements and components of circuit switched domain in comprehensive detail (Lempiäinen and Manninen, 2003).

- Mobile Switching Center (MSC)

First and the foremost element of circuit switching domain is related to MSC. MSC is significantly defined as the one in which any particular telecommunication switch and exchange, which is present in entire cellular network architecture, is capable of working within the location database. In addition to this, it has been observed that the primary task of MSC is to significantly not only route but switch and transit the data, which is passed through the process of circuit switching (Vranjes, et.al, 2010). This data is found to be evidently received from the Radio Network Controller (RNC). Moreover, it has also been observed that the data is received from RNC to another significant element, which is named as Public Switched Telephone Network (PSTN). The entire

receiving process is done through the Gateway MSC (GMSC). Where, it may not be wrong to say that MSC is considered to be one of the core elements of the entire GSM network (Rappaport, 2002).

- Visitor Location Register (VLR)

It has been observed that the concept of Visitor Location Register may aptly be defined as the one in which the system efficiently keeps all the information and knowledge about the customers linked to the roaming mobile. The information here is required for the purpose of call handling as well as for operations such as mobility management. Additionally, it has been observe d that whenever the MSC finds another mobile subscriber who is not registered before, the system automatically updates the Home Location Register (HLR). In addition to the upgrade of HLR of the mobile subscriber, the system also generated a new record in the visitor location register (Al-khaldi, et.al, 2012).

- Gateway MSC (GMSC)

In addition to the elements discussed in the aforementioned paragraphs, it has been observed that another main significant element is considered to be GMSC. This is the concept in which it has been observed that the primary routing element significantly switched the data and information between the UTMS and PSTN. It is significant to notice that this switching is considered to be two-dimensional, that is, the data and information may significantly transfer from the PSTN or ISDN to the UMTS. In addition to this, it is significant to notice that the GMSC is considered to be such MSC, which significantly determines that the mobile subscriber used is located in which position (Lempiäinen and Manninen, 2001).

It has also been found that in the GMSC system all the cellular calls and also the calls that are made from the PSTN to the mobile calls, all are effectively routed through GMSC. Moreover, it may not be wrong to say that this element of CN aims to terminate the PSTN signaling as well as a number of different traffic formats. It then works to significantly convert these protocols so that they may be used in mobile networks. In addition to this, it effectively interacts with the HLR so that it may be enabled for the purpose of obtaining routing information. This is found to be done for the mobile terminated calls. Moreover, the main elements of the packed switched domain are discussed in the following paragraphs (Laiho, et.al, 2007).

- Serving GPRS Support Node (SGSN)

It may not be wrong to say that SGSN is fairly responsible for the purpose of delivering the packet switched data, which is received from RNC. This is found to be received from RNC to the GPRS support Node or from this node to the RNC. One of the primary tasks of the SGSN include packet routing, packet transfer, management of the mobility of the packets and the management of a number of different logic links (Bhalla & Bhalla, 2010).

- Gateway GPRS Support Node (GGSN)

It has been observed that in the similar way as GMSC, GGSN is also considered to be one of the main routing elements for the packet switched elements. The only difference between them is that the former is considered to be a routing element for circuit switched data to PSTN network whereas, GGSN is considered to be a routing element for a comprehensive packet switched data. This packet switched data is significantly linked to the Ethernet network of the UMTS network. In addition to the circuit and packet switched elements, it has been observed that the main shared elements of these domains are EIR, HLR and AUC. Each one of these are discussed in the following lines (UMTS Forum, n.d).

- Equipment Identity Register (EIR)

It may not be wrong to say that this register is considered to be the one in which there is a database, which significantly aims to keep a list of the mobile phones. The mobile phones are identified by their IMEI. Additionally, the list of these mobile phones is to be banned from the entire network and also from monitoring. It has also been observed that the International Mobile Equipment Identity (IMEI) of the mobile phones starts to check against the EIR as soon as the mobile requests services from a certain network. After this, it significantly decides whether it is suitable to allow the service or it is appropriate to ban the service network (Heiska, 2002).

- Home Location Register (HLR)

The HLR is considered to be a central database whose primary function is to significantly contain all the information of each and every mobile phone subscriber who is appropriate for the purpose of authorization to any particular network. Moreover, to make it more precise and concise, it may not be wrong to say that HLR is capable of storing all the information related to the SIM card. This SIM card is officially issued by the mobile phone operator. HLR also has the responsibility of the maintenance of the user subscription information (Mishra, 2004).

- Authentication Center (AUC)

AUC is responsible for the purpose of authenticating each and every SIM card that is making an attempt to connect itself to the GSM network. Additionally, after the connection or a link is established between the two, the HLR is permitted to carry out its task related to the management of the SIM card and the services (Vranjes, et.al, 2010).

3) UMTS Terrestrial Radio Access Network (UTRAN)

The RAN, which is an abbreviation for Radio Access Network is considered to be a UTRAN – (UMTS Terrestrial Network). In addition to this, the radio access is also called as a UTRA. UTRA is a short form of UMTS Terrestrial Radio Access. This is fairly considered to be one of the main sections of the entire mobile network evolution. In addition to this, it may not be wrong to say that a number of different changes are taking place in the segment for the purpose of evolution of the new technology. Additionally, it has been observed that UTRAN significantly consists of two main elements. One is RNC – (Radio Network Controller) and the other is Node B (Laiho, et.al, 2007).

- RNC – (Radio Network Controller)

It is one the main elements in the UTRAN, which is considered to be a governing factor. In addition to this, the primary function of RNC is to determine the controlling and management of the Node Bs. The function of the Base Station Controller in the networks o f GSM and GPRS is considered to be the same as that of the RNC in the system of UMTS. Additionally, it has been observed that the RNC is considered to be connected to the Circuit Switched Core Network via MSC. MSC is also effectively named as the Media Gateway. It is also connected through the Packed Switched Core Network (Lempiäinen and Manninen, 2001).
The management of the radio channels as well as the terrestrial channels is considered to be done by the RNC. In addition to this, RNC is also responsible for the purpose of maintaining the mobility. The functionality that is related to the mobility management includes radio resource control, admission control, allocation of the available channels and controlling of various types of power settings. Moreover, there are also other functions that are performed by the RNC. Some of these include packet scheduling, broadcasting of the signals, power control related to the configuration of open loop and controlling of load associated to the system (Bhalla & Bhalla, 2010).

- Node B

Furthermore, it has been observed that Node B is the part of the UMTS network, which is related to the provision of an effective and efficient radio link between the network and the User Equipment. The functions that are associated to the Base Transceiver Station (BTS) in the network of GSM or GPRS are provided by the Node B which is present in the UMTs network. It has been observed that the system of the Node B is significantly correlated to the GSM BTS. The reason to this is the fact that through this, there may be a reduction in the cost of UMTS implementation (Anonymous, n.d.).

4) User Equipment (UE)

This type is effectively called as the user equipment. In addition to this, it has been observed the UMTS UE is typically based on the same principles as that of the GSM MS. This may aptly be defined as the separation or segregation between the mobile equipment and the UMTS subscriber. In addition to this, it has been observed that the USIM card is found to contain the subscriber-related information which is linked to the concepts such as authentication and encryption (Heiska, 2002).

5) Benefits of UMTS

It has been observed that there are a number of different benefits that are related to the UMTS network. Some of these are described in brief detail in the following lines.

- It is a subscription, which is always-on;
- It is personalized and has a feature that is aware of the location;
- It operates in real-time and is considered to be flexible;
- A wider range of services that are related to multimedia;
- Data rates are higher for a large number of users;
- Network efficiencies are improved, which are considered to have a positive impact on lowering the cost in the long-term;
- There is a feature of IP transport in not only Access but core networks as well;
- The support and the transport functionalities are found to be in separation; and

- Mobile devices have this feature of IP multimedia services (Lempiäinen and Manninen, 2003).

6) Pitfalls in UMTS

In addition to the advantages discussed in the aforementioned paragraph, there are certain pitfalls and challenges that are related to UMTS. The following points aim to discuss them briefly (UMTS Forum, n.d).

The overall financial cost of the entire cellular infrastructure is extremely high because it has the costs of the upgrading data base station incorporated in it;

- The structure is designed as such that it needs a number of different handsets;
- Here, it has been observed that the power consumption related to the system is high;
- It requires closer base stations and therefore they are considered to be expensive; and
- The costs that are related to licensing of the spectrum, network deployment and the handset subscribers are found to be tremendous (Mishra, 2004).

7) Teleservices of UMTS

In addition to the discussion above, it may not be wrong to say that the teleservices are considered to be one of the most important factors that are created individually by the service provider. Through the use of bearer servicers, the tele-services are created individually. Additionally, it has been observed that there are around four standards including speech, SMS, emergency calls and fax (Laiho, et.al, 2007).

8) Applications of UMTS

Certain key applications of UMTS include fast internet, streaming and downloading, videoconferencing, services that are location oriented and mobile entertainment.

B.HSDPA

HSDPA stands for High Speed Downlink Packet Access. It is considered to be a mobile telephony protocol, which is an effective mobile telephony protocol. It is also called as a 3.5G, which is helpful for the provision of smooth evolutionary paths. In addition to this, these evolutionary paths are related to the formation of 3G networks that are based on UMTS. Due to these paths, it has been observed that the speeds associated to data transfer have become significantly higher (Lempiäinen and Manninen, 2001).

There are certain capabilities that are associated to the HSDPA. Some of them include a common and shared channel of HS-DSCH. This has the ability to be shared by a number of users at one time. It has also the capability of having a usability related to fast scheduling. In addition to this, the capability is also related to AMC – (Adaptive Modulation and Coding). AMC is a concept, which is related to the fast link adaptation. It means that the factors such as modulation and a number of different coding formats have the ability to change themselves in relation to the differences in the channel conditions. This significantly leads to a comparatively higher data rate for different users that are found to have certain favorable radio conditions (Al-khaldi, et.al, 2012). The key difference between the UMTS and the HSDPA is that the Release 99 of the former only has Quadrature Phase Shift Keying. On the other hand, it has been observed that HSDPA has the ability to provide usability of 16 QAM. This happens when the link is extremely robust and then it promptly leads to a significant increase in the rate of the data being transferred (Bhalla & Bhalla, 2010).

1) Key Features of HSDPA

It may not be wrong to say that the key features that are associated with the HSDPA are discussed in the following lines.

- A reduction in delay due to the errors in transmission;
- A decrease in the HO failure;
- It significantly improves the resources management;
- An effective adaptation to the local features of the environment;
- Time interval of the transmission is considered to be short; and
- Fast ARQ and scheduling (Rappaport, 2002)

2) Advantages of HSDPA

Following are some of the various advantages provided by the HSDPA:

- HSDPA serves best for such applications that have exceedingly changeable and uneven requirements of bandwidth;
- It offers precise delays that in turn facilitates novel applications, for instance; interactive networked games;

- HSDPA makes use of comparatively shorter length of frame thereby showing quicker response to the issues occurring in the radio channel; and
- It facilitates the network to make use of data schedulers which provide increased priority to real time applications (Anonymous, n.d.).

3) Disadvantages of HSDPA

The only disadvantage found to be documented in the literature offered by the HSDPA is that it is not appropriate for such applications that have requirements of low bandwidth, for instance; voice (Heiska, 2002).

4) HSDPA Architecture

It has been observed that one of the main responsibilities of Node B is to carefully handle and manage ARQ – (Automatic Repeat Request). It also works to control the priority handling as well. In addition to this, the overall scheduling strategy of the architecture determines the behavior of the entire system. Moreover, the RNC in the system still has the responsibilities related to RLC through retaining Rel'99. It also takes care of the process related to the retransmission of HS-DSCH in the case if Node B fails to transmit. This happens when the process the maximum number of retransmissions from the physical layer (Rappaport, 2002).

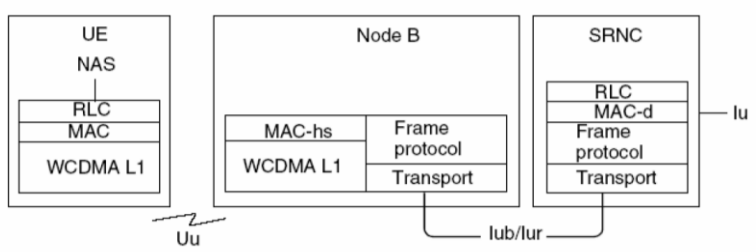

Fig. 2 HSDPA Architecture (Source: Google)

C. HSUPA

These are considered to be the technologies of 3.75G, which are effectively higher and way beyond a number of different 3G technologies. Full form of HSUPA can be defined as High Speed Uplink Packer Access and it is found to be UMTS uplink evolution technology. Moreover, it has been observed that the technologies of the HSUPA and HSDPA are directly linked and complimentary to each other (UMTS Forum, n.d). It has been observed that this optimized HSUPA has the ability to enhance the symmetric data rates such as emails in the mobile and video and gaming and data applications that vary from person to person. Some of the most important technical capabilities of HSUPA include a separate and dedicated uplink channel, an extensive introduction to H-ARQ and a fast and prompt Node B scheduling (Anonymous, n.d.).

In addition to this, it has been observed that the in contrast to HSDPA, HSUPA has a dedicated channel and furthermore, there is a series of channel for the purpose of traffic and signal so that all the uplink capabilities can be significantly improved. In addition to this, it has been observed that HSUPA can be used in a number of different applications for the purpose of improving the DVD quality, live and heavy streaming and the ability to play real-time games in different modes readily and easily. Furthermore, if HSUPA is compared to the technology of dedicated channel, it may be found that the former has the ability to enable a comparatively higher user throughput as well as enhanced and optimized experiences (Lempiäinen and Manninen, 2003).

1) Improvement of the Network Performance

It may not be wrong that with the introduction of the HSUPA, the overall performance of the uplink can be significantly improved. Moreover, it has the ability to enhance the quick transmission of the data as well as improve the retransmission of the failed data. In addition to this, it also helps in the effective reduction of the time delay experienced in the transmission. It has been observed that the fastest uplink data rate can be 5.76Mbps and the delay in the transmission is considered to be decreased by around 40% (Mishra, 2004).

2) Specifications near Completion

The specifications of the HSUPA are observed to be made after HSDPA. Moreover, the HSUPA specifications were worked on by 3GPP first in R6. Later, in the year 2005, one of the wireless performance and protocols named as RAN WG2 was frozen, which marked the onset of the completion of the specifications for HSUPA (Lempiäinen and Manninen, 2003).

3) Advantages associated to HSUPA

It may not be wrong to say that there are a number of different advantages that are related to the implementation of HSUPA. First and the foremost advantage is related to the significant enhancement in the data transmission rate. However, it is possible only when the conditions are good, when the conditions are not favorable, the rate of the data transmission decreases significantly. In comparison to the transmission rates of DCH in R99, it has been observed that not only HSDPA but also HSUPA shows an enhanced and better performance of the system (Heiska, 2002).

4) Uplink fast scheduling adopts the decentralized scheduling strategy

In RNC, it is found that the scheduling strategy related to the decentralization is in constant opposition to the strategies of centralization. On the basis of the demodulation performance, it is observed that the RNC strategy of centralization is used for the scheduling f the data transmission rate. Moreover, one of the main advantages of the decentralization of Node B is that the data transmission rate of the users can be significantly scheduled up to 2 ms (Lempiäinen and Manninen, 2003).

5) HARQ

It stands for Hybrid Automatic Repeat Request. It has been observed that it is an error correction technology. It is based on the principle of FEC. FEC stand for Forward Error Code. With the use of HARQ technology, it may be assured that the multi-path features can be altered and changed (Mishra, 2004).

6) 2ms short frame

Due to 2ms short frame, it may be assured that the Round Trip Time (RTT), can be significantly reduced in HARQ. Moreover, it is controlled by Node B, which shortens the fast scheduling response time (Lempiäinen and Manninen, 2003).

7) HSUPA supports uplink soft handoff

The user receives control signals related to Node B cell scheduling from every radio link. After this, the transmission rate signals are combined together from different cells with the help of user terminal (Mishra, 2004).

8) New entities and channels

There are some additional entities in the HSUPA, for instance MAC-e and MAC-es, for the order of supporting the fast scheduling of NodeB; at the UTRAN side, the MAC-e entity is shifted to NodeB. The MAC-es, for the order of supporting the large scale diversity allied to the HSUPA, is located on the SRNC. The transmission channel E-DCH is set up for the purpose of bearing and transmitting the blocks of data amid the physical layer and the MAC layer. The E-DPDCH and E-DPCCH are supplemented in the physical layer in the uplink direction (Lempiäinen and Manninen, 2003). The uplink E-DPCCH is employed for bearing the associated signaling, whereas the E-DPDCH is employed for bearing the uplink transmission data of the users of HSUPA. There is a common channel, E-AGCH; the user service of E-DCH is attached to the current user cell and is used for indicating the maximally usable rate of transmission, and generally slow regulation is out into place. There is a dedicated channel, E-RGCH, which may be employed for adjusting the uplink transmission rate of the user terminal in two milliseconds. There is another dedicated channel, downlink E-HICH, which may be employed for indicating if the processed data that the user receives is the appropriate message of ACK/NACK or not (Rappaport, 2002).

9) Enhancement of HSUPA Over HSDPA

The transmission of UEs that are connected to the same Node B are considered to be sequential in time, therefore, it may not be wrong to say that the channelization will not be exchanged between them. A comparatively softer handovers are permitted in the HSUPA in contrast to HSDPA. Moreover, here the main Node B will be able to send commands of not only power-up but power-down also. However, apart from this, all other Node B's are able to send power down commands only (Mishra, 2004).

D. Applications of 3G

Some of the major applications of 3G technology include acquisition of relevant mobile information and facilitation of mobile transactions. Other applications of the 3G technology include mobile entertainment and wireless communication and advertising.

E. QoS in 3G

The primary function of the QoS is to efficiently define the features related to service delivery. Through this, it may have an intense impact on the perception of service. The key features also include availability of the service, consistent delivery and assuring quality of information (Lempiäinen and Manninen, 2003).

VI. Result

In this paper will compare between UMTS, HSDPA and HSUPA in term of the coverage by signal level and overlapping zone where we used ATOLL simulation.

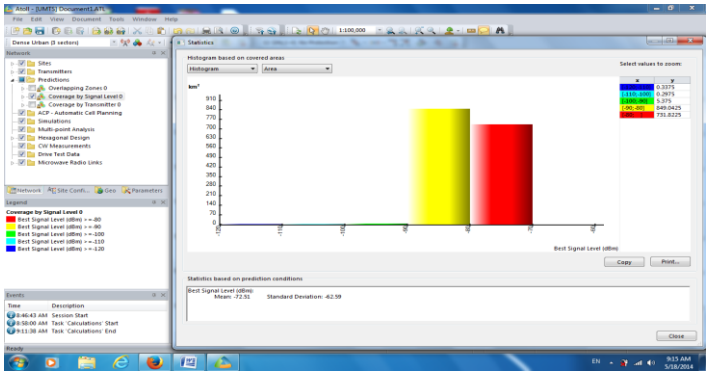

Fig. 3 Coverage by Signal in UMTS

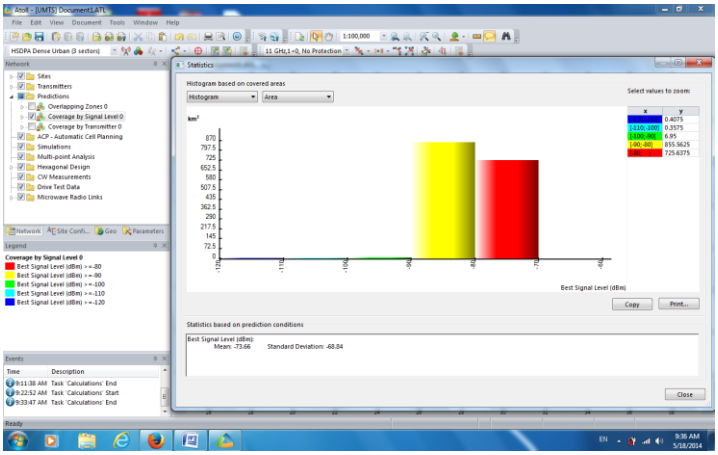

Fig.4 Coverage by Signal in HSDPA

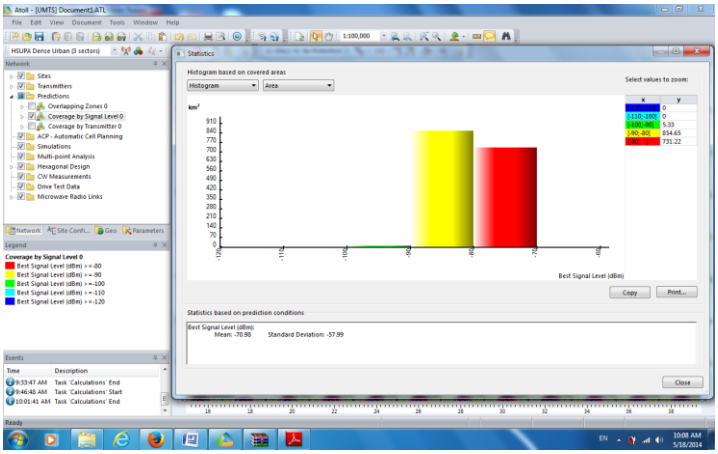

Fig. 5 Coverage by Signal in HSUPA

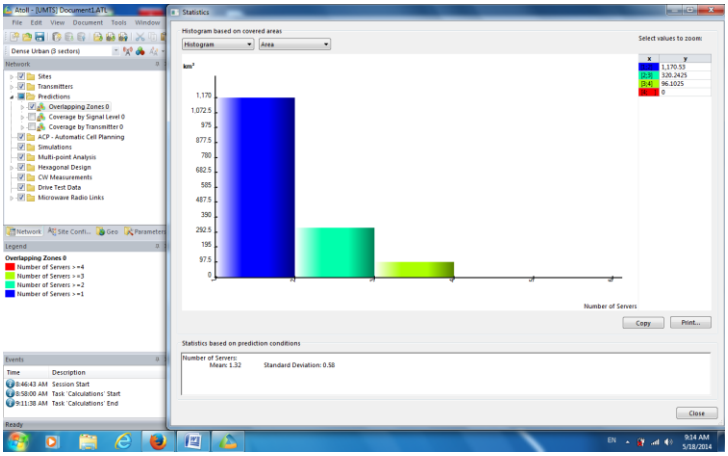

Fig. 6 Overlapping Zone in UMTS

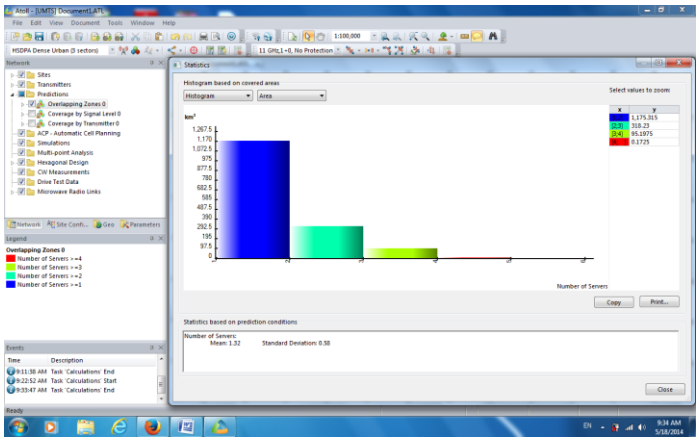

Fig. 7 Overlapping Zone in HSDPA

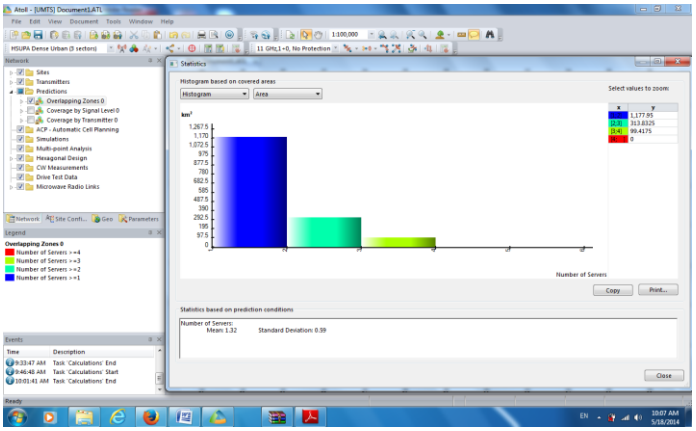

Fig.8 Overlapping Zone in HSUPA

VII. Conclusion

From the above detailed discussion, it is evident that the application of 3G is considered to be extremely important and crucial for enhancing the speed of the data rate. Additionally, 3G has its usefulness in the field of wireless advertising, mobile information, instant communication and in different business solutions. In addition to this, which is a 3G wireless system is considered to be one of the most efficient examples of 3G technology. In addition to this, it may not be wrong to say that UMTS is productive because it can be personalized and also it is used in a way that it enables a higher data rate for a large number of users.

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