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Characterization of TDMA and W-CDMA Performance based on their Key Performance Indicators (KPIs)

Emuoyibofarhe O.J, Oladosu J. B., Ogunleye O. , Alamu F.O
Department of Computer Science and Engineering,
Ladoke Akintola University of Technology, Ogbomoso, Nigeria

ABSTRACT

Mobile Wireless Communication presents the users with seamless communication where possible. TDMA is the Multiple Access Scheme used in GSM while 3G system uses W-CDMA. The former is designed majorly for voice and a little of data. Due to the increased in number of phone users and the services enjoyed by the users, subscribers have demanded for non-voice services, mobile extensions to fixed-line services and richer mobile content. This has caused the network operators to develop 3G system with the goal of providing a network infrastructure that can support a much broader range of services than existing systems.
This paper presents a characterization of the two wireless systems performance based on their key performance indicators (KPIs). This Characterization was carried out around their TCH Availability, Call Drop Rate, Call Set-up Success Rate (CSSR), Handover Rate, and TCH Traffic.
From the collected data, the two systems were analyzed and the analysis shown that W-CDMA provides a network infrastructure that can support a much broader range of services than existing systems (GSM) because the main forces behind development of the third generation systems (3G) have been driven by the second generation systems' low performance data services, incompatible service in different parts of the world, and lack of capacity.

Keywords: *TDMA, W-CDMA, Call Drop Rate, Call Set-up Success Rate (CSSR), Handover Rate*

1. INTRODUCTION

The third generation or 3G is now the generally accepted term used to describe the next wave of mobile networks and services. The next wave, second generation (2G), arrived in the late 1980s and moved towards a digital solution which gave the added benefit of allowing the transfer of data and provision of other non-voice services.

Of these, the global system for mobile communication (GSM) has been the most successful, with its global roaming model. (Jeffrey,2 004). 3G leverages on the developments in cellular to date, and combines them with complementary developments in both the fixed-line telecom networks and the world of the internet.

The result is the development of a more general purpose network, which offers the flexibility to provide and support access to any service, regardless of location. These services can be voice, video or data and combinations thereof, but, as already stated, the emphasis is on the service provision as opposed to the delivery technology.

2. RADIO-CHANNEL ACCESS SCHEMES

The radio spectrum is a scarce resource. Its usage must be carefully controlled. Mobile cellular systems use various techniques to allow multiple users to access the same radio spectrum at the same time. In fact, many systems employ several techniques simultaneously (Korhonen, 2003). In a TDMA system (Figure 1), the entire available bandwidth is used by one user, but only for short periods at a time. The frequency channel is divided into time slots, and these are periodically allocated to the same user so that other users can use other time slots. Separate time slots are needed for the uplink and the downlink. GSM is based on TDMA technology. In GSM, each frequency channel is divided into several time slots (eight per radio frame), and each user is allocated one (or more) slot(s). In a TDMA system, the used system bandwidth is usually divided into smaller frequency channels. So in that sense GSM is actually a hybrid FDMA/TDMA system (as that shown in Figure 2), as are most other 2G systems.

In a CDMA system all users occupy the same frequency at the same time, no time scheduling is applied, and their signals are separated from each other by means of special codes (Figure 3).

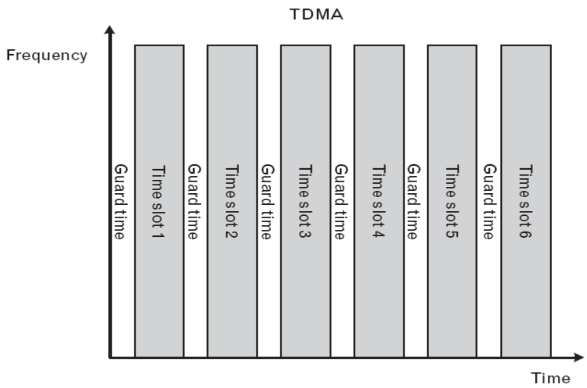

Figure 1: TDMA: The Entire Available Bandwidth Is Used By One User, But Only For Short Periods At A Time. (Korhonen, 2003)

Each user is assigned a code applied as a secondary modulation, which is used to transform a user's signals into a spread-spectrum-coded version of the user's data stream. The receiver then uses the same spreading code to transform the spread-spectrum signal back into the original user's data stream. These codes are chosen so that they have low cross-correlation with other codes.

This means that correlating the received spread-spectrum signal with the assigned code dispreads only the signal that was spread using the same code. All other signals remain spread over a large bandwidth. That is, only the receiver knowing the right spreading code can extract the original signal from the received spread-spectrum signal. In addition, as in TDMA systems, the total allocated bandwidth can be divided into several smaller frequency channels. The CDMA spread spectrum scheme is employed within each frequency channel. This scheme is used in the UMTS Terrestrial Radio Access Network (UTRAN) frequency-division duplex (FDD) mode. The TDD mode uses a combination of CDMA, FDMA, and TDMA methods, because each radio frame is further divided into 15 time slots.

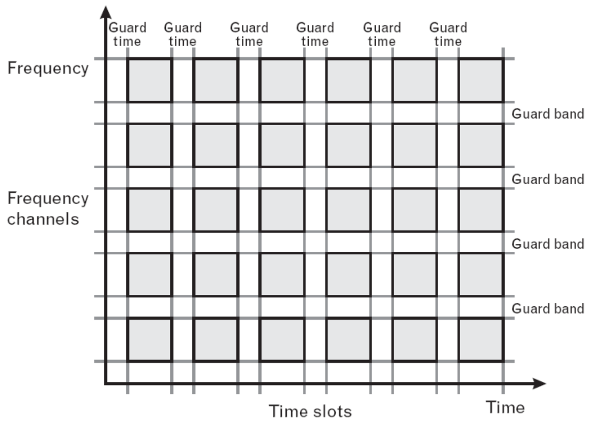

Figure 2: Hybrid FDMA/TDMA systems. (Korhonen, 2003)

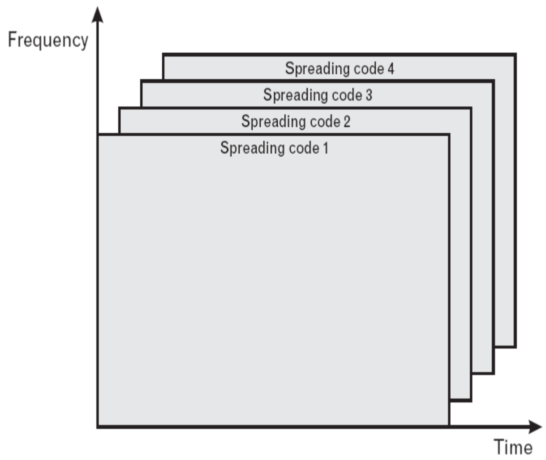

Figure 3 CDMA System: all users occupy the same frequency at the same time, but their signals are separated from each other by means of special codes. (Korhonen, 2003)

3. MODULATION TECHNIQUES

Modulation can be defined as the process of putting useful information on a carrier that can be transmitted from one point to another. This information can be voice, data or signalling data. Data modulation is always in digital sense. Modulation techniques used in GSM and 3G were reviewed.

Modulation in 3G

According to Jeffrey et al. (2004), UMTS defines the use of quadrature phase shift keying (QPSK) modulation for the air interface. With a QPSK modulation scheme, the complex signal that results from the spreading function is split by a serial to parallel converter into a real and an imaginary branch, each of which is multiplied with an oscillator signal. However, the imaginary branch is 90◦ out of phase with the real branch. When summed, the resulting signal can have four possible phase angles, each of which represents two data bits.

Figure 4 illustrates the general principle. QPSK modulation is specified for use in both the uplink and the downlink; however, the use of the QPSK modulation scheme does present some difficulties in the uplink. Consider that the amplifier is at a maximum output power and needs to change its signal by 180◦. This consumes a considerable amount of power in the amplifier to retain the linearity of the signal, particularly across such a wide frequency band, and most of this power ends up wasted as heat. This is not so difficult a problem at the BTS, but is quite impractical at the UE, where cost, power consumption, battery life and heat dissipation are all significant issues. A common solution to this problem is to use offset quadrative phase shift keying (QPSK) in the uplink instead. With offset QPSK, there is a delay introduced into the imaginary branch to offset the phase shifting of this branch relative to the real branch. The result is that when a 180◦ phase shift is required, the shift is performed in two steps of 90◦. QPSK modulation provides a one-to-one relationship between the bit rate of an unmodulated signal and the symbol rate after modulation. In practice, this means that a 3.84 Mcps spread signal entering the modulator will emerge as a 3.84 MHz signal. In the course of the modulation process, pulse shaping is also performed. WCDMA uses a root-raised cosine filter with a roll-off of 0.22. A modulated signal with this roll off, plus the provision of a guard band between neighbouring frequencies, equates to the 5 MHz of spectrum allocated per WCDMA carrier (Figure 3.5). For frequencies licensed to the same operator, there can be less than 5 MHz spacing between carriers. However, the centre frequency must lie on a 200 kHz raster. (.Jeffrey et al.(2004).

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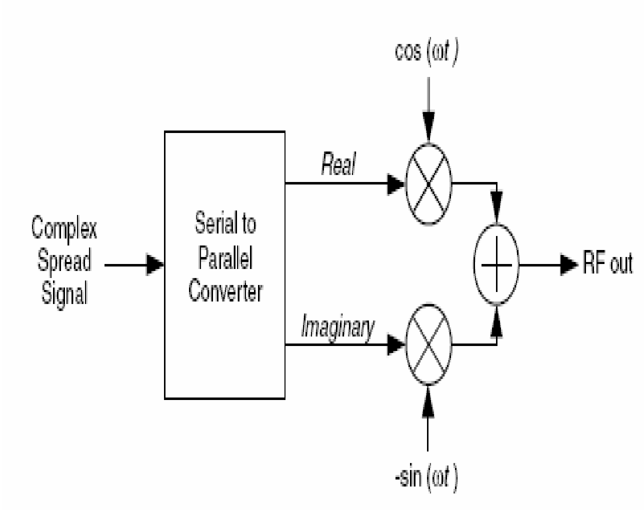

Figure 4: QPSK Modulation Principle. This modulation technique is used in 3G system. (Jeffrey et al, 2004)

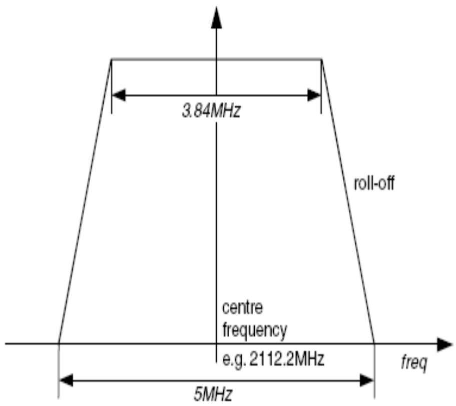

Figure 5: 5 MHz frequency band allocated per WCDMA carrier. (Jeffrey et al, 2004).

Modulation in GSM

Andrew (2003) stated that GSM uses a modulation format called GMSK (Figure 6). The transmit rate of the GSM system is 270.833 Kbps, while the bandwidth of the signal is 200 kHz. Thus, the modulation efficiency of GSM (data rate divided by bandwidth) is 1.35 bps/Hz. This is a lower efficiency than NA-TDMA (1.6 bps/Hz).

One of the trade-offs for the lower modulation efficiency is that GSM uses a constant signal envelope, which means less battery drain and more robustness in the presence of interfering signals. In having a constant signal envelope, the constellation diagram of a GSM signal is a circle, and, thus, unlike NA-TDMA and CDMA, constellation analysis will not tell a technician very much about the quality of modulation.

Another important difference between GSM and NA-TDMA pertains to the downlink transmission. In NA-TDMA, the base station transmitted all slots.

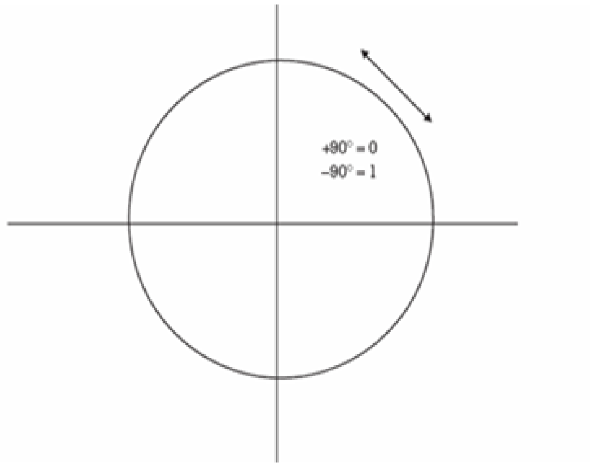

Figure 6 GSM uses GMSK modulation. Amplitude remains constant during phase shifts of ± 90 .The constellation of a GSM signal thus resembles a circle. (Andrew, 2003)

4. POWER CONTROL

Power Control in a WCDMA

Power control in a WCDMA system is crucial to its successful operation. This is because each handset transmits on the same frequency and at the same time as other handsets. Each of the handsets therefore generates interference, raising the overall noise level in the cell, and the base station has to be able to distinguish a particular user out of this interference.

If a single mobile device is transmitting with too much power, or is physically closer to the BTS, this may drown out the other UEs. Conversely, if a UE is transmitting with too little power, or is physically further away, the base station will never hear it. This is commonly referred to as the near–far problem. There are two main concerns regarding power control: distance from the base station and fast fading. Within the WCDMA system three types of power regulation are used, open loop, inner loop and outer loop power control. The key goals of power control are to:

- provide each UE with sufficient quality regardless of the link condition or distance from the BTS;
- compensate for channel degradation such as fast fading and attenuation;
- optimize power consumption and hence battery life in the UE. (Jeffrey, 2004).

Power control in a TDMA

Like the American standards, GSM can use a variety of power levels and can change these power levels

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during a call. The GSM standard allows for five classes of mobile stations divided by the maximum amount of power they can output (Figure 7).

The highest class outputs 20W (43 dBm), and the lowest class outputs 800 mW (29dBm). Below the maximum power are 16 power levels with 2-dB steps (a dynamic range of 30 dB). Typically, mobile stations have a maximum power of 2W, but as terminals only transmit one eighth of the time (one burst of the eight), the average maximum transmit would be 250 mW. GSM also uses a process called *discontinuous transmission* (DTX). It is important to limit the amount of power transmitted in the system—co channel interference is a primary cause of suboptimal capacity—so limiting the overall output power is important. An equally important reason to limit transmit power is to save battery life. One way of doing this is to use the lowest power level needed to communicate without errors. DTX is another method of lowering power output. Similar to the variable vocoder used in CDMA, the DTX system detects if there is voice activity (of course, distinguishing between voice and noise is an important consideration). If there is no voice activity, then the transmitter can shut down. The other intrinsic benefit of DTX is that the talk time of the handset will increase dramatically. An interesting part of this process is the concept of comfort noise. If the transmitter is turned off at the mobile station, the other party would hear dead silence, a rather disturbing sensation. To help the situation, engineers came up with the concept of comfort noise, to ensure the other party that the call is still connected. There are five power classes in GSM; these indicate the peak power in the class. All are capable of the levels below their peak ratings. (Andrew,2003).

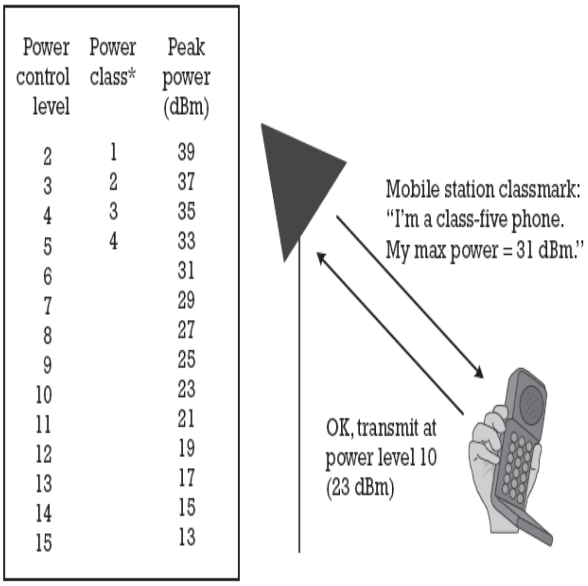

Figure 7: Shows the various power classes and the 15 power levels used in GSM. (Andrew, 2003)

5. DATA COLLECTION AND TREATMENT

Data were collected from the wireless service provider and the data contained the Handover rate, TCH traffic, Call Drop etc. These data were analyzed using Excel to examine the performance of the two systems. The characteristics got for the two systems will be presented in the result and discussion portion of this paper.

6. RESULTS

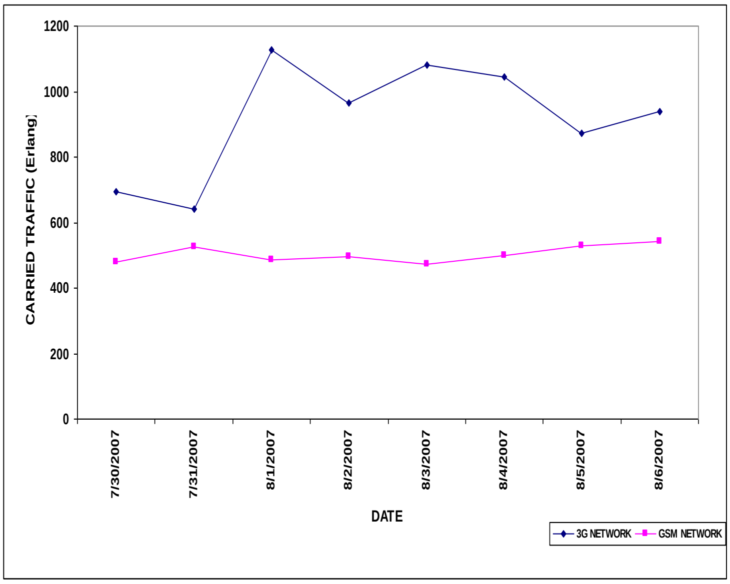

Figure 8: 3G and GSM Traffic Performance

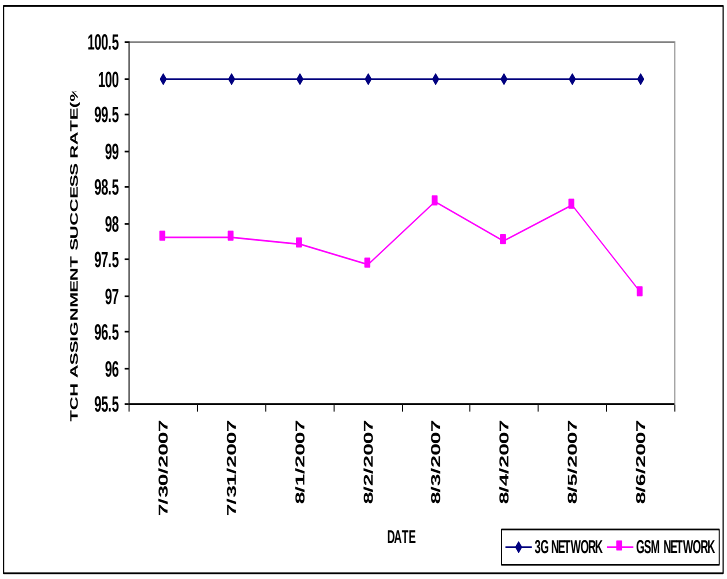

Figure 9: 3G and GSM TCH Assignment Success Rate

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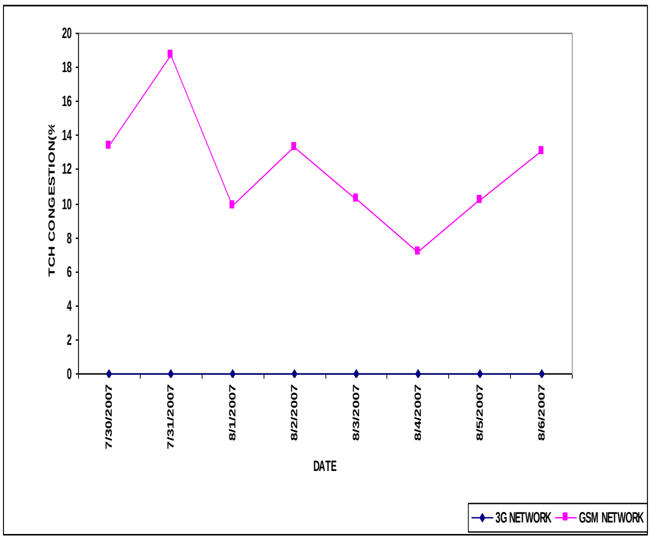

Figure 10: 3G and GSM TCH Congestion

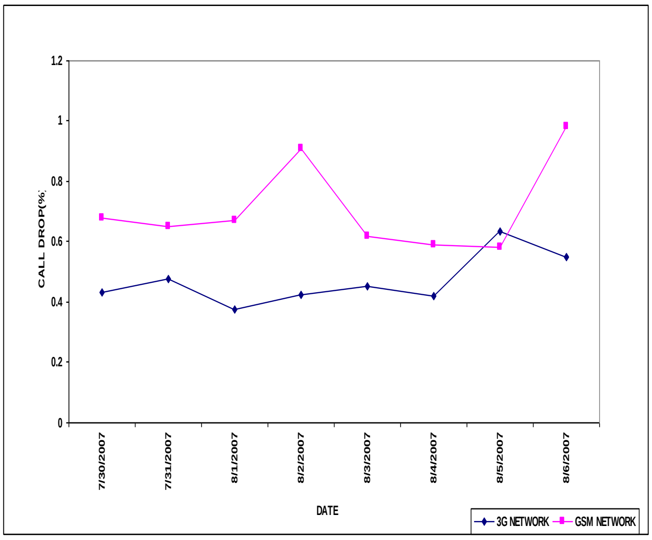

Figure 11: 3Gand GSM Call Drop Rate

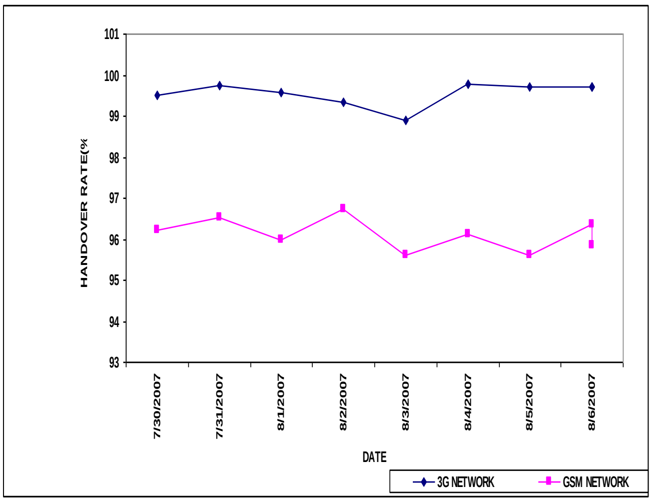

Figure 12: 3G and GSM Handover Success Rate

7. DISCUSSION OF RESULTS

Data Analysis Result Discussion

The discussions of the results obtained from the treated data are as follow:

Figure 8 shows the carried traffic performance of the two systems (both GSM and 3G).
Figure 9 shows the TCH Assignment Success Rate (Call Setup Success Rate) of the two systems (both GSM and 3G).
Figure 10 shows the TCH Congestion of the two systems (both GSM and 3G).
Figure 11 shows the Call Drop Rate of the two systems (both GSM and 3G).
Figure 12 shows the Handover Success Rate of the two systems (both GSM and 3G).
From the plotted graphs, it can be seen that 3G system has the best of all compared to GSM system. Several features in 3G system accounted for its best. Some of those features are:

i) Fast Power Control.
ii) Soft Handover.
iii) Rake receiving.
iv) Bandwidth Efficient.
v) Resilient to Noise.

FAST POWER CONTROL

3G system controls power fast compared to GSM system, this minimizes the interference in the system. Since the User Equipments (mobile station or phone) cannot transmit at the same power level, MS far from BTS must transmit with considerably higher power than those close to the BTS. This will avoid domination of cells by users closest to the node B (Base Transceiver Station).3G system makes sure all the signals be it far or close to the BTS arrive at the receiver with the same signal power but, GSM system cannot control fast, all those transmitted signals. This causes increase in the level of interference in GSM system and reduces the number of traffic it carries – the number of calls per hour multiplied by the average holding time.

SOFT HANDOVER (SHO)

In 3G system, UE is connected simultaneously to more than one BTS and this caused the connection not to get lost if one branch gets shadowed. This feature allows 3G system to have the best Handover characteristics and minimal Drop Call Rate.

But GSM system has Hard Handover (HHO) feature in which the UE stops transmission on one frequency before moving to another frequency. This GSM feature also accounts for its poor Handover and Drop Call Rate. See Figures 11 and 12

RAKE RECEIVING

GSM system does not have this feature but 3G has. Since 3G signals transmit with the same frequency, it is possible the original transmitted signal reflects in different directions on its way to the receiver. 3G system uses Rake Receiver to gather all the reflected signals in other to avoid the receiver receiving several copies of the original transmitted signal. This led to 3G having higher TCH Assignment Success Rate and lower TCH Congestion Rate. Figures 9 and 10

BANDWIDTH EFFICIENCY

3G network can carry twice the data rate in the same bandwidth (2bits/sec/Hz) whereas, GSM network can only carry approximately 1 bit/sec/Hz. This allows 3G system to have better carried traffic compared to GSM system. See figure 8

8. CONCLUSIONS

In this paper we have evaluated the two systems - W-CDMA and TDMA based on the key performance indicators, we then analyzed both systems.
The results of the two system-WCDMA and TDMA revealed that WCDMA system renders more general purpose network, which offers the flexibility to provide and support access to any service, regardless of location. These services can be voice, video or data and combinations thereof due to the characteristics and features embedded in it. The features include fast power control, soft handover, efficiency in bandwidth usage, resilient to noise, rake receiving and a lot more.

REFERENCES

[1] Savo G. Glisic (2003). *Adaptive WCDMA: Theory And Practice.* John Wiley & Sons, Ltd, University of Oulu, Finland. England.

[2] Jeffrey,Mather and Coope (2004). Convergence technologies For 3G networks IP, UMTS, EGPRS and ATM. England . John Wiley & Sons Ltd.

[3] Roger L. Freeman(2005). Fundamentals of Telecommunications. Second Edition. Published by John Wiley & Sons, Inc., Hoboken, New Jersey. Canada.

[4] Korhonen, Juha(2003). Introduction to 3G mobile communications —2nd (Artech House mobile communications series). 685 Canton Street Norwood

[5] Miceli, Andrew(2003). Wireless technician's handbook/Andrew Miceli.—2nd ed. (Artech House mobile communications series) 685 Canton Street Norwood.

[6] Tarmo Anttalainen (2003). Introduction to telecommunications network engineering— 2nd ed.

[7] Telecommunications: A Beginner's Guide Hill Associates, INC. 2002 The McGraw- Hill Companies, Inc.