

# Multi-Frequency Scenario within UMTS/3G

Muhammad Arshad<sup>1</sup>, N M Saad<sup>1</sup>, Nasrullah Armi<sup>1</sup>, M Shuja uddin<sup>1</sup>, Farhan Ahmed Siddqui<sup>2</sup>

<sup>1</sup>Department of Electrical and Electronics Engineering, Universiti Teknologi PETRONAS, Bandar Seri Iskandar  
31750 Tronoh, Perak, MALAYSIA

<sup>2</sup>Department of Computer Science, University of Karachi, Karachi 75850, Sindh, Pakistan

[muarshad74@gmail.com](mailto:muarshad74@gmail.com), [naufal\\_saad@petronas.com.my](mailto:naufal_saad@petronas.com.my), [nasrullah.armi@gmail.com](mailto:nasrullah.armi@gmail.com), [msudm80@gmail.com](mailto:msudm80@gmail.com),  
[farhan@uok.edu.pk](mailto:farhan@uok.edu.pk)

**Abstract** - The IMT-2000 standard UMTS of (Universal Mobile Telecommunications System) is based on Wideband CDMA (Code Division Multiple Access). To access a shared transmission channel for multiple users, UMTS exploit Code Division Multiple Access (CDMA). Multi-user interference is a critical issue in CDMA, limited user, cell Capacity and limiting spectral efficiency dramatically. The manner of used multiple carriers can provide capacity increases over and above a simple doubling of capacity. Models involving power, signaling and cell size design will be developed to determine the best configuration for improved capacity within the UMTS/3G network. This paper will explain the analytical calculation of Multi-Frequency scenario within UMTS/3G for user capacity enhancement with number of services in cells of clusters.

**Index Terms** — Mobile Communication, 3G Networks, Cellular communication, System capacity enhancement and Wideband communication network.

## I. INTRODUCTION

The cell concept arises due to the need of spectrum sharing which is a bonus and a limited resource in wireless communication. It focuses on the ability to control RF energy in a small area of space (called cell) for the same spectrum can be reused as many times as desired, within each cell. Therefore, system capacity can be increased, making the cells smaller in size and divided by the cells in an area into smaller pieces (called sectors). Users of a cell are allowed to access available spectrum by using a multiple access. In cellular mobile communications, widely adopted multiple access techniques are frequency division multiple access (FDMA), multiple access Time division (TDMA) and Multiple Access Code Division (CDMA) [1, 2, and 5].

### A. First Generation Systems (1G)

Analogue systems were used in early age of cellular system and require FDMA with Frequency Division Duplexing (FDD). Voice only deal in these systems and the voice signal was frequency modulated. Advanced Mobile Phone System (AMPS) was the first successful cellular system. FDMA/FDD access technique was used with 20 MHz channel bandwidth in 800 MHz band. Later AMPS operated at 25 MHz bandwidth in every direction, for uplink (from mobile to base station) and downlink (from base station to mobile) frequency allocations are 824-849 MHz and 824-849 respectively.

### B. Second Generation Systems (2G)

Digital technology has been introduced to increase the strength against interference and reduced bandwidth of the user spectrum and provided greater capacity by using signal processing techniques. The capacity of second generation systems is 3 to 4 times higher than first generation exclusive of adding new base stations. Digital systems are more protected to noise; 15 dB signal-to-noise (SNR) ratios are satisfactory in digital systems but 18 dB is required for the analog systems. This has allowed the use of smaller cluster reuse, thereby increasing system capacity. Access technique which used in second generation is TDMA or a combination of TDMA and FDMA.

### C. Third Generation Systems (3G)

Wideband Code Division Multiple Access (WCDMA) is the air interface adopted in third generation cellular system. There are minor differences between the IMT-2000 and cdma2000. According to Telecommunications Industry Association (TIA) cdma2000 specification was:

- At least 144 Kbps in a vehicular situation
- 384 Kbps in a pedestrian location
- 2048 Kbps for indoor office atmosphere.

The main idea was to provide 144 Kbps and 384 Kbps bit rates with approximately 5 MHz bandwidth. Universal Mobile Telecommunication Systems (UMTS) is the third generation mobile communication, European standard by Europe Telecommunications Standards Institute (ETSI). UMTS belong to IMT-2000 family standard better known as 3G defined by International Telecommunication Union (ITU) [2, 5, and 7].

This paper describes detailed analytical calculations of Multi-Frequency scenario within UMTS/3G networks to discover the best configuration for improved capacity inside the network by the help of involving power, signaling and cell size design. The rest of the paper is ordered as follows: section II and III describes the multi-carrier CDMA and WCDMA capacity respectively, multi-frequency scenarios calculations are analyzed in section IV, and section V concludes the paper.

## II. MULTI-CARRIER CDMA

UMTS Terrestrial Radio Access (UTRA) FDD and TDD modes in the global ITU-R IMT-2000 CDMA framework, the third mode is the Multi-carrier (MC) CDMA mode, based on the cdma2000 multi-carrier opportunity being standardized by the 3rd Generation Partnership Project 2 (3GPP2). The MC

mode, part of IS-2000 specification series, was considered as the way for 3G evolution for operators with an existing IS-95 (or 1X) network, especially if a third generation network is to be deployed on the same frequency spectrum as an existing IS-95 network. MC is the name of the mode of transmission downlink direction, instead of a multi-carrier broadband (up to 12) simultaneously with the narrow-band CDMA carriers will be sent to each base station. Each carrier's chip rate is 1.2288 Mcps, the same as IS-95 chip rate. The uplink direction is direct spread, very similar to UTRA FDD, with multiple chip rates of 1.2288 Mcps. The first ITU release of cdma2000 will adopt up to three carriers (known as 3X mode) at a chip rate up to 3.6864 Mcps. The term 'MC mode' hereafter will refer to the MC mode (3X) as defined in the cdma2000 standard [3, 4].

The MC mode has been considered to provide an evolutionary path for existing IS-95 systems. Three narrowband IS-95/1X carriers, each with 1.25 MHz, are bundled to form a multi-carrier transmission in the downlink with approximately 3.75 MHz (3X) bandwidth in a 5 MHz deployment. Fig. 1 explains the MC mode and IS-95 spectrum usage relationship.

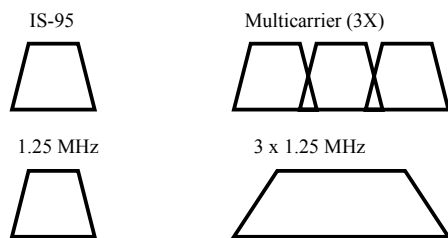


Figure 1. MC mode and IS-95 spectrum usage relationship

In terms of signal bandwidth, there is not much difference between the MC mode's multi-carrier (uplink) chip rate of 3.6864 Mcps and UTRA FDD's 3.84 Mcps. [6, 7, 8, 10 and 11].

### III. CAPACITY OF WCDMA

Capacity of WCDMA cellular systems is investigated for the radio interface of 3G cellular systems. This portion provides an overview of 3G cellular systems and to draw attention to the IMT-2000 standard, using the WCDMA air interface. WCDMA is also known as UTRA system. WCDMA radio interface is widely accepted for the third generation cellular systems. Its data are received for a common standards body known as 3GPP (3rd Generation Partnership Project). The operations of 3G radio access are Frequency Division Duplex (FDD) and Time Division Duplex (TDD) [2, 13].

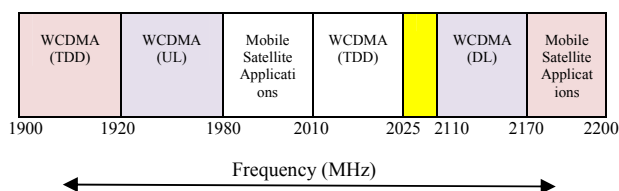


Figure 2. Spectrum of UTRA

Spectrum of UTRA is described in fig. 2. An associated band 1920-1980 MHz and 2110 - 2170 MHz is reserved for FDD uplink (UL) and downlink (DL) operations accordingly, and the remaining unpaired TDD bands allocated space. UL and DL signals are transmitted with different carrier frequencies F1 and F2 respectively to distinguish the guard band frequency in FDD mode. On the other hand, UL and DL transmission in TDD mode is the same vector k, but at different times, separated by a guard time.

Intermediate carrier WCDMA spectrum raster is 200 kHz and can vary from 4.2 to 5.4 MHz. Operator 15 MHz band in three-layer cell technology, the result showed that the greater the distance between the operators can be applied as a single band operator in order to avoid interference between operators. Inter-frequency measurement and delivery WCDMA supports multiple cellular carriers and the floor technology. UTRA defines the number of air interface physical channels [9, 11, and 12].

### A. Interference

The interferences are Intra-cell, Inter-cell and background noise due to thermal activity. Quantitative analysis showed that the amount of thermal noise is often negligible compared to interference occur due to the presence of other users in the system.

The cell itself (Intra) inverse relationship interference consists of overlapping signals from other mobile stations (MSs) is a base station (BS) receiver. Almost all the sounds received BS receiver due to signal interference. Maximize the system capacity is depend upon the received signal power same at the BS and as low as likely while achieving satisfactory link performance [8 and 15].

### B. Multi-Carrier Interference

The effects of adjacent channel interference between two frequencies on neighboring frequencies are studied. Interference from adjacent channels must be considered because it will affect all wideband systems where large guard bands are not possible, and WCDMA is no exception. Spectrum is wasted due to the isolation of adjacent frequency in the frequency domain by large guard bands. Stringent requirements for spectrum mask requirements and a transmitter of high selectivity for a receiver in the mobile station and base station would guarantee low adjacent channel interference. But these requirements have a major impact, particularly on the implementation of a small WCDMA mobile station.

Adjacent Channel Interference Ratio (ACIR) is defined in relation to the transmission power, measured when the receiver adjacent to the channel filter(s). This interference is due to non-perfectness of transmitter and faulty receiver filtering. The performance of adjacent channel performance is limited to a mobile phone in both uplink and downlink. By the help of radio network planning and some resource management to ensure that adjacent channel interference does not affect the performance of WCDMA network. If the operator (s) using the frequency bands adjacent co-location of

their base stations, either in the same places or use the same poles, along with the channel interference problems can be avoided, because the levels power of received transmissions of the two operators are then very similar. Since there are no large differences in power, adjacent channel attenuation of 33 dB is sufficient to avoid any problem of adjacent channel interference [7, 14, and 15].

WCDMA carrier spacing is 5.0 MHz, but 200 kHz raster can be adjusted depending on the needs of adjacent channel interference. Using a higher carrier frequency, adjacent channel interference can be reduced. If the operator has two carriers in the same base station then the carrier spacing between them might be smaller than 4.0 MHz because the adjacent channel interference completely avoided. In this case, the greater distance carrier can be reserved between operators. Fig. 3 gives explanation of raster between frequency bands.

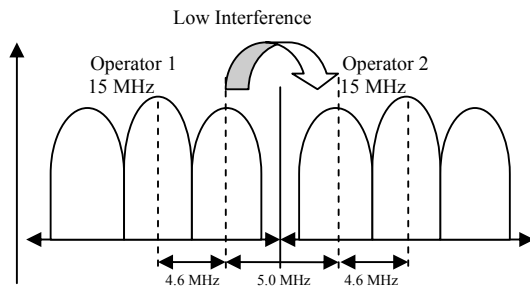


Figure 3. Operator's band and between operators carrier spacing selection

Moreover, the solutions of network design, radio resource management can be effectively used to resolve the problems of inter-operator interference. The following solutions for the management of radio resources to avoid interference from adjacent channels in addition to the solutions of network design:

- ❖ To provide higher selectivity and more protection against interference achieved by inter-frequency handover to another frequency;
- ❖ The allocation of additional power connection at downlink to offset the effect of the interference;
- ❖ Decrease the downlink packet data connection, the instantaneous bit rate to provide more processing to tolerate more interference;
- ❖ To offer more processing gain must reduce the downlink AMR voice bit rate [6, 8, and 9].

### C. Dimensioning

Dimensioning of WCDMA radio networks is a process through which possible configurations and the amount of network equipment are estimated based on the needs of the operator associated with it.

Capacity:

- ❖ Available of spectrum;
- ❖ Forecast of subscriber growth;
- ❖ Traffic density information.

Coverage:

- ❖ Coverage regions;

- ❖ Area type information;
- ❖ Propagation conditions.

Quality of Service:

- ❖ Area location probability;
- ❖ Blocking probability;
- ❖ End user throughput.

The particular parameter of WCDMA is *Radio Link Budgets* that are not used in a GSM TDMA-based radio access. The most important ones are: *Interference Margin* is needed in the link budget calculation because the loading of the cell, the load factor and concern coverage. The more loading is allowed in the system, the greater the interference margin needed in the uplink and the smaller the coverage area. Typical values of the margin of interference in the affairs of limited coverage are 1.0 to 3.0 dB, which corresponds to 20-50% load. *Fast Fading Margin* is necessary for the mobile station transmission, means to ensure an adequate closed loop fast power. This is especially true for slow moving pedestrians to where the fast power control is able to effectively compensate for the rapid disappearance. Typical values of the fast fading margin are 2.0 to 5.0 dB for slow moving. *Soft Handover Gain* Handovers – soft or hard – provide a gain next to slow fading ( $\frac{1}{4}$  lognormal fading) by dropping the essential log-normal fading margin. This is due to slow fading is partly uncorrelated between the base stations, mobile phone select the better base station to perform a handover. Soft handover provides macro-diversity for fading quickly, reducing the demand  $E_b/N_0$  in relation to a radio link, as a result of macro-diversity combining. Total soft handover should be between 2.0 and 3.0 dB, including a victory against a slow and fast fading. Three examples of link budgets are given for typical UMTS services are: 12.2 kbps voice service using AMR speech codec, 144 kbps real-time data and 384 kbps non-real-time data, in an urban macro-cellular environment at the planned uplink noise rise of 3 dB. An interference margin of 3 dB is reserved for the uplink noise rise. Table 1 and 2 briefly described the link budget assumption values of mobile station and base station [3, 6, 9, and 12].

TABLE 1. MOBILE STATION ASSUMPTION VALUES

|                            | Speech Terminal | Data Terminal |
|----------------------------|-----------------|---------------|
| Maximum Transmission Power | 21 dBm          | 24 dBm        |
| Antenna Gain               | 0 dBi           | 2 dBi         |
| Body Loss                  | 3 dB            | 0 dB          |

TABLE 2. BASE STATION ASSUMPTIONS VALUES

|              |                                                                                         |
|--------------|-----------------------------------------------------------------------------------------|
| Noise Figure | 5.0 dB                                                                                  |
| Antenna Gain | 18 dBi (3-Sector Base Station)                                                          |
| $E_b/N_0$    | Speech: 5.0 dB<br>144 Kbps real-time data: 15 dB<br>384 Kbps non-real time data: 1.0 dB |
| Cable Loss   | 2.0 dB                                                                                  |

#### D. Load Factors

The second phase of dimensioning is the evaluation of traffic handled by the base station site. When the frequency reuse of a WCDMA system, system interference is generally limited and the amount of interference and delivered cell capacity should be estimated. The theoretical spectral efficiency of a WCDMA cell can be calculated from the load equation, the uplink load factor can then be written as:

$$\eta_{UL} = (1 + i) \cdot \sum_{j=1}^N L_j = (1 + i) \cdot \sum_{j=1}^N \frac{1}{1 + \frac{E_b/N_0}{R_j} \cdot v_j}$$

Load equation is commonly used to make the semi-analytic capacity to predict the average WCDMA cell, without entering the simulation capabilities at the system level. This equation can be used to load the aim of predicting the ability of cells and increase the sound planning of the design process. The uplink and downlink load factor parameters are explained in Table 3 and 4.

TABLE 3. UPLINK LOAD FACTOR PARAMETERS

|       | Definitions                                                                                                                                                              | Recommended Values                                                                                       |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| N     | Number of user per cell                                                                                                                                                  |                                                                                                          |
| Vj    | Activity factor of user j at physical Layer                                                                                                                              | 0.67 for speech, assumed 50% voice activity and DPCH overhead during DTX 1.0 for data                    |
| Eb/No | Signal energy per bit divided by noise spectral density that is required to meet a predefined Block error rate, BLER. Noise includes both thermal noise and interference | Dependent on service, bit rate, multi-path fading channel, receive antenna diversity, mobile speed, etc. |
| W     | WCDMA chip rate                                                                                                                                                          | 3.84 Mcps                                                                                                |
| Rj    | Bit rate of user j                                                                                                                                                       | Dependent on service                                                                                     |
| i     | Other cell to own cell interference ratio seen by the base station receiver                                                                                              | Macro cell with omnidirectional antennas: 55 %. Macro cell with 3 sectors: 65 %.                         |

The downlink load factor can be defined based on a similar principle as for the uplink, although the parameters are slightly different [2, 5, 6, 7, and 16]:

$$\eta_{DL} = \sum_{j=1}^N v_j \cdot \frac{\left(\frac{E_b}{N_0}\right)_j}{\frac{W}{R_j}} \cdot [(1 - \alpha_j) + i_j]$$

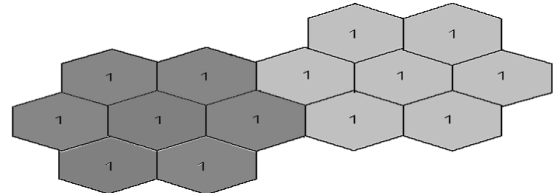
TABLE 4. DOWNLINK LOAD FACTOR PARAMETERS

|    | Definitions                                 | Recommended Values                                   |
|----|---------------------------------------------|------------------------------------------------------|
| N  | Number of user per cell                     |                                                      |
| Vj | Activity factor of user j at physical Layer | 0.58 for speech, assumed 50% voice activity and DPCH |

|       |                                                                                                                                                                          |                                                                                                          |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
|       |                                                                                                                                                                          | overhead during DTX 1.0 for data                                                                         |
| Eb/No | Signal energy per bit divided by noise spectral density that is required to meet a predefined Block error rate, BLER. Noise includes both thermal noise and interference | Dependent on service, bit rate, multi-path fading channel, receive antenna diversity, mobile speed, etc. |
| W     | WCDMA chip rate                                                                                                                                                          | 3.84 Mcps                                                                                                |
| Rj    | Bit rate of user j                                                                                                                                                       | Dependent on service                                                                                     |
| Ij    | Ratio of other cell to own cell base station power, received by user j.                                                                                                  | Each user sees a different ij, depending on its location in the cell and log-normal shadowing.           |
| Aj    | Orthogonality of channel of user j.                                                                                                                                      | Dependent on the multipath propagation 1: fully orthogonal 1-path channel 0: no orthogonality            |
| A     | Average orthogonality factor in the cell                                                                                                                                 | ITU Vehicular A channel: ~50% ITU Pedestrian A channel: ~90%                                             |
| I     | Average ratio of other cell to own cell base station power received by user. Own cell interference is here wideband.                                                     | Macro cell with omnidirectional antennas: 55 %. Macro cell with 3 sectors: 65 %.                         |

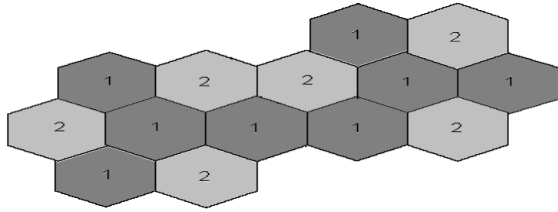
#### IV. MULTI-FREQUENCY SCENARIOS

##### A. Single Frequency in all Cells of Clusters:



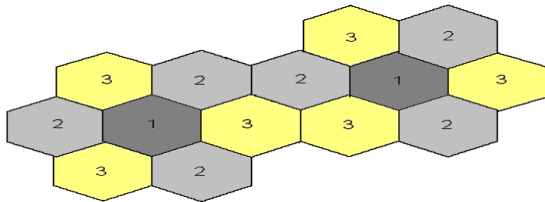
- ❖ For Downlink Voice Service
  - Cell Load 50 %
  - Interference 33 %
  - 73 Simultaneously Users.
  - Cell Load 50 %
  - Interference 50 %
  - 64 Simultaneously Users.
  - Throughput 780 Kbps.
- ❖ For Uplink Voice Service
  - Cell Load 50 %
  - Interference 33 %
  - 103 Simultaneously Users.

### B. Multi-Frequency in all Cells of Clusters:



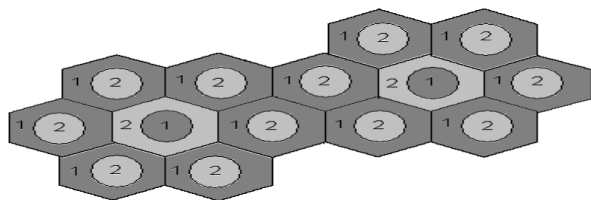
- ❖ For Downlink Real Time Data Service
  - Cell Load 60 %.
  - Interference 22 %.
  - 10 Simultaneously Users.
  - Cell Load 70 %.
  - Interference 33 %.
  - 11 Simultaneously Users.
  - Throughput 1400 Kbps.
- ❖ For Uplink Real Time Data Service
  - Cell Load 70 %.
  - Interference 33 %.
  - 16 Simultaneously Users.

### C. Multi-Frequency in all Cells of Clusters:



- ❖ For Downlink Voice Service
  - Cell Load 50 %.
  - Interference 10 %.
  - 88 Simultaneously Users.
  - Cell Load 60 %.
  - Interference 10 %.
  - 107 Simultaneously Users.
  - Throughput 1305 Kbps.
- ❖ For Uplink Non-Real Time Service
  - Cell Load 40 %.
  - Interference 10 %.
  - 3 Simultaneously Users.

### D. Micro-Macro Cells Frequency:



- ❖ For Downlink Non-Real Time Data Service
  - Load Factor 60 %.
  - Interference 27 %.
  - 3 Simultaneously Users.
  - Load Factor 75 %.
  - Interference 27 %.
  - 4 Simultaneously Users.
  - Throughput 1536 Kbps.
- ❖ For Uplink Non-Real Time Service
  - Load Factor 60 %.
  - Interference 27 %.
  - 4 Simultaneously Users.

Table 5 and 6 explain the comparison chart of uplink and downlink frequencies for voice, real-time and non real-time service.

**TABLE 5. COMPARISON CHART FOR UPLINK VOICE TRAFFIC (CELL LOAD 50% AND 60%)**

| NO. OF FREQUENCY                       | INTRA AND INTER CELL INTERFERENCE | MEASURING METRICS |                    |
|----------------------------------------|-----------------------------------|-------------------|--------------------|
|                                        |                                   | USERS             | THROUGHPUT (Kbps)  |
| Single Frequency                       | 50 %                              | 64 and 77         | 780 and 939 Kbps   |
| Multi Frequency (2)                    | 37 %                              | 70 and 85         | 854 and 1037 Kbps  |
| Multi Frequency (3)                    | 10 % (Only Intra)                 | 88 and 107        | 1073 and 1305 Kbps |
| Multi Frequency (Micro and Macro Cell) | 23 % (Only Intra)                 | 94 and 119        | 1146 and 1451 Kbps |

**REAL TIME TRAFFIC (CELL LOAD 60 % AND 70 %)**

| NO. OF FREQUENCY                       | INTRA AND INTER CELL INTERFERENCE | MEASURING METRICS |                    |
|----------------------------------------|-----------------------------------|-------------------|--------------------|
|                                        |                                   | USERS             | THROUGHPUT (Kbps)  |
| Single Frequency                       | 65 %                              | 8 and 9           | 1152 and 1296 Kbps |
| Multi Frequency (2)                    | 33 %                              | 10 and 11         | 1400 and 1584 Kbps |
| Multi Frequency (3)                    | 10 % (Only Intra)                 | 12 and 14         | 1728 and 2016 Kbps |
| Multi Frequency (Micro and Macro Cell) | 25 % (Only Intra)                 | 10 and 13         | 1400 and 1872 Kbps |

**NON-REAL TIME TRAFFIC (CELL LOAD 40 % AND 70 %)**

| NO. OF FREQUENCY | INTRA AND INTER CELL INTERFERENCE | MEASURING METRICS |                   |
|------------------|-----------------------------------|-------------------|-------------------|
|                  |                                   | USERS             | THROUGHPUT (Kbps) |
| Single Frequency | 45 %                              | 2 and 3           | 768 and 1152 Kbps |

|                                        |                   |         |                   |
|----------------------------------------|-------------------|---------|-------------------|
| Multi Frequency (2)                    | 35 %              | 2 and 3 | 768 and 1152 Kbps |
| Multi Frequency (3)                    | 10 % (Only Intra) | 2 and 4 | 768 and 1536 Kbps |
| Multi Frequency (Micro and Macro Cell) | 27 % (Only Intra) | 2 and 4 | 768 and 1536 Kbps |

**TABLE 6. COMPARISON CHART FOR DOWNLINK**

| <b>VOICE TRAFFIC (CELL LOAD 50% AND 60%)</b> |                                          |                          |                          |
|----------------------------------------------|------------------------------------------|--------------------------|--------------------------|
| <b>NO. OF FREQUENCY</b>                      | <b>INTRA AND INTER CELL INTERFERENCE</b> | <b>MEASURING METRICS</b> |                          |
|                                              |                                          | <b>USERS</b>             | <b>THROUGHPUT (Kbps)</b> |
| Single Frequency                             | 50 %                                     | 88 and 106               | 1073 and 1293 Kbps       |
| Multi Frequency (2)                          | 37 %                                     | 100 and 122              | 1220 and 1448 Kbps       |
| Multi Frequency (3)                          | 10 % (Only Intra)                        | 139 and 167              | 1695 and 2037 Kbps       |
| Multi Frequency (Micro and Macro Cell)       | 23 % (Only Intra)                        | 142 and 178              | 1732 and 2171 Kbps       |

| <b>REAL TIME TRAFFIC (CELL LOAD 60 % AND 70 %)</b> |                                          |                          |                          |
|----------------------------------------------------|------------------------------------------|--------------------------|--------------------------|
| <b>NO. OF FREQUENCY</b>                            | <b>INTRA AND INTER CELL INTERFERENCE</b> | <b>MEASURING METRICS</b> |                          |
|                                                    |                                          | <b>USERS</b>             | <b>THROUGHPUT (Kbps)</b> |
| Single Frequency                                   | 65 %                                     | 10 and 12                | 1400 and 1728 Kbps       |
| Multi Frequency (2)                                | 33 %                                     | 13 and 16                | 1872 and 2304 Kbps       |
| Multi Frequency (3)                                | 10 % (Only Intra)                        | 18 and 21                | 2592 and 3024 Kbps       |
| Multi Frequency (Micro and Macro Cell)             | 25 % (Only Intra)                        | 10 and 13                | 2160 and 2592 Kbps       |

| <b>NON-REAL TIME TRAFFIC (CELL LOAD 40 % AND 70 %)</b> |                                          |                          |                          |
|--------------------------------------------------------|------------------------------------------|--------------------------|--------------------------|
| <b>NO. OF FREQUENCY</b>                                | <b>INTRA AND INTER CELL INTERFERENCE</b> | <b>MEASURING METRICS</b> |                          |
|                                                        |                                          | <b>USERS</b>             | <b>THROUGHPUT (Kbps)</b> |
| Single Frequency                                       | 45 %                                     | 2 and 4                  | 768 and 1536 Kbps        |
| Multi Frequency (2)                                    | 35 %                                     | 2 and 4                  | 768 and 1536 Kbps        |
| Multi Frequency (3)                                    | 10 % (Only Intra)                        | 3 and 6                  | 1152 and 2304 Kbps       |
| Multi Frequency (Micro and Macro Cell)                 | 25 % (Only Intra)                        | 3 and 5                  | 1152 and 1920 Kbps       |

## V. CONCLUSION

In this analytical calculation, we reviewed the basics of wireless communication to raise the question of the capacity of CDMA cellular systems. In particular, we considered the WCDMA cellular systems capacity where the user non-uniform distributions (hot spots) are involved in the coverage area. System capacity was evaluated by the number of users in a cell is both an acceptable radio frequency planning. Intra and Inter cell interference were considered during the calculation of base stations, and also examined the random distribution of mobile equipments in home and neighbors cells, free space propagation environment and user activity and system activity factors. However, more research is needed to categorize and calculate the nature and system capacity enhancement within UMTS/3G networks.

## REFERENCES

- [1] William C Y Lee, "Overview of Cellular CDMA", IEEE Transactions on Vehicular Technology, Vol. 40, No. 2, May 1991, pp 291-302
- [2] Harri Holma and Antti Toskala, "WCDMA for UMTS", Wiley England 2000
- [3] T. Nguyen, P. Dassanayake and M. Faulkner, "Use of Adaptive Sectorisation for Capacity Enhancement in CDMA Cellular Systems with Non-uniform Traffic," Wireless Personal Communications, vol. 28, pp. 107-120, February 2004. Kluwer Academic Publishers.
- [4] T. Nguyen, P. Dassanayake and M. Faulkner, "Capacity of CDMA Cellular Systems with Adaptive Sectorisation and Non-uniform Traffic," IEEE Proc. VTC Fall 2001, Atlantic City, NJ USA, October 7 - 11, Vol. 2, pp.1163-1167.
- [5] Clint Smith and Daniel Collins "3G Wireless Networks" McGraw Hill 2002
- [6] T. Nguyen, P. Dassanayake and M. Faulkner, "Computer Modelling of 3G Cellular Traffic", 2nd ATerc Telecommunications and Networking Conference, Esplanade Hotel, 16-18 October 2002, pp.146-149.
- [7] T. Ojanpera and R. Prasad, Wideband CDMA for Third Generation Mobile Communications. Artech House, Boston, MA, 1998.
- [8] T. Nguyen and T. Nguyen and P. Dassanayake, "Estimation of Intercell Interference in CDMA Macro Cells", Australian Telecommunications Networks and Applications Conference, 8 - 10 December 2003, Melbourne Australia.
- [9] T. Nguyen, P. Dassanayake and M. Faulkner, "System Activity in WCDMA System with Packet Mode Traffic," 3rd ATerc Telecommunications and Networking Conference, 11-12 December 2003, Melbourne Australia.
- [10] Vijaya Chandran Ramasami "Capacity of CDMA systems" EECS, The University of Kansas
- [11] Mariusz Głabowski, Maciej Stasiak, Arkadiusz Wiśniewski and Piotr wierzykowski, "Uplink blocking probability calculation for cellular systems with WCDMA radio interface and finite source population", Mobile and Wireless Networks, HET-NET Publications
- [12] T. Dean, P. Fleming, and A. Stolyar, "Estimates of multicarrier CDMA system capacity," in IEEE Proc. Winter Simulation Conf., vol. 2, Washington, D.C., 1998, pp. 1615-1622.
- [13] T. Ojanpera and R. Prasad, Wideband CDMA for Third Generation Mobile Communications. Artech House, 1998.
- [14] Hsiao-Hwa Chen, Jun-Feng Yeh, "A Multicarrier CDMA Architecture Based on Orthogonal Complementary Codes for New Generations of Wideband Wireless Communications", 2003 IEEE 58<sup>th</sup> Vehicular Technology Conference
- [15] Durantini A., Mazzenga, F., Santella G., "A Semi-Analytic Approach for CDMA Systems Performance Evaluation with Adjacent Channel Interference", Journal, IEEE, Italy, 2004
- [16] Kari Heiska, "Effect of adjacent IS-95 Network to WCDMA uplink capacity," Vehicular Technology, IEEE Transactions on. Vol. 52, Issue 2, March 2003 pp. 326 - 332