

## **Traffic Evaluation in Mobile Wimax**

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**Abstract:-** The basics for constant growth of broadband wireless remain sound. As said by the Ericsson's official forecasts, the worldwide wireless internet broadband connectivity reaches to 420 million users by the end of 2012. The chance for WiMAX to provide those who want to change to broadband service is vast in several parts of the globe where wire line technologies may not be feasible. This paper (Evaluation of traffic load for Multi traffic Users in Mobile WiMAX) is organized to read in detail the service provision capabilities of Mobile WiMAX innovative technology in deep details. A detailed extract of the technical topics of IEEE-802.16e-2005 standard is gathered to provide the reader with a practical concept of Mobile WiMAX technology and intended to gather the required knowledge for WiMAX planning problem. A modern technique to calculate the system's actual throughput and a traffic model for varied application users are projected with a step by step description to obtain an algorithm to find out the maximum number of subscribers that all specific Mobile WiMAX sector may possibly support and tries to implement the entire algorithm for different system parameter and traffic cases to make it easy for Mobile WiMAX planning problem. Also we have introduced the regularly used propagation models that outfit the WiMAX applications. This method would facilitate those operators that have planned to execute a wide coverage network in a city. Using this method, service providers would be able to approximate the number of base stations and for reason of profitability and the network investment

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### **I. INTRODUCTION**

The first requirement of city Area Wireless Network was accepted under the IEEE 802.16 standard by means of product official recognition name of WiMAX. The IEEE 802.16-2004 standard was built up to put in NLOS applications support to fundamental standard. The standard serves nomadic and fixed users in the frequency range of 2 – 11 GHz .To put in mobility to wireless entrance, the WiMAX, IEEE 802.16e-2005 requirement was defined to utilize frequencies less than 6 GHz.

There are many physical-layer options, inside IEEE 802-16 standard. In the same way, there are several options for duplexing, MAC architecture, frequency band of operation, etc. In reality, you could say that IEEE 802.16 is a set of standards. To give interoperability the WiMAX medium describes a limited number of certification profiles and system profiles. A System Profile describes the subset of MAC-layer features and mandatory and optional physical chosen by the WiMAX medium from the IEEE 802.16e-2005 or 802.16-2004 standard. Two different system profiles are described: one depend on IEEE 802.16e-2005 scalable OFDMA PHY, called the mobility system profile and other one depend on IEEE 802.16-2004, OFDM PHY, called the fixed system profile . The Mobile WiMAX standard has been built up to be the best wireless broadband standard for portable devices enabling a new age of high throughput and high delivered bandwidth together with outstanding spectral efficiency when contrasted to 3G mobile wireless technologies.

### **II. PRACTICAL BANDWIDTH EVALUATION**

We have established two major suppositions based on practical cases to obtain our sector's capacity calculation algorithm. We have described a model for modulation distribution in sequence to get our system's raw data-rate. And other supposition is a model for subscribers' traffic demand based on their application distribution. Our algorithm defines the system's actual throughput by detecting the overheads and removing them to gain the useful available data-rate.

In a 5mS TDD frame the uplink and downlink sub frames are prorated with a DL:UL ratio and are separated with an 11.4  $\mu$ S transmission gap. These two sub frames have some distinctive and identical overheads. Hence, we divide our whole frame into these two DL and UL partitions and examine the available bandwidth.

Our **initial inputs** to the algorithm and the first steps that are needed to be taken:

### III. CHANNEL BANDWIDTH

Provides us with a number of critical parameters. In that paper 5 and 10 MHz are measured that are the frequently used bandwidths. Calculating the channel width we can decide regarding the number of the data subcarriers ( $FFT_{used}$ ) and the sub channels via PUSC variation in each one direction.

**G value:** is the index to describe the cyclic prefix duration to determine the symbol time ( $T_s$ ). In Mobile WiMAX certification the useful symbol duration ( $T_b$ ) is fixed to 91.4  $\mu$ S for all possible bandwidths.

Having the  $FFT_{used}$  and  $T_s$  and based on the modulation distribution supposition we can get channel's raw bandwidth.

### IV. DL:UL RATIO

To get the Raw BW in each one direction it is used to calculate the duration of DL sub frame ( $T_{DL}$ ) by multiplying it to  $T_f = 5\text{mS}$  (the frame duration) and UL duration as  $T_{UL} = UL / (UL+DL) \times T_f$ .

### V. UL/DL TRAFFIC RATIO

Traffic ratio is used to get the UL traffic demand depend on the DL demand, whereas the system parameters of the DL direction are accessible.

our algorithm is to calculate the useful bandwidths in DL and UL directions separately by defining and removing the overheads. At the end these available bandwidths will be compared with the ones already obtained in last section in concern with subscribers traffic demand.

### VI. DOWNLINK

Step by step downlink overheads removals are examined in order to introduce the downlink useful bandwidth.

**Figure below** summarizes the approach of DL useful channel width calculation. In continuation the algorithm is explained in details.

The first column of **Figure 2.4** is used to calculate raw bandwidth ( $BW_1$ ) based on the system parameters obtained from initial inputs as explained procedure at the beginning of this section.

### VII. INCOMPLETE SYMBOLS

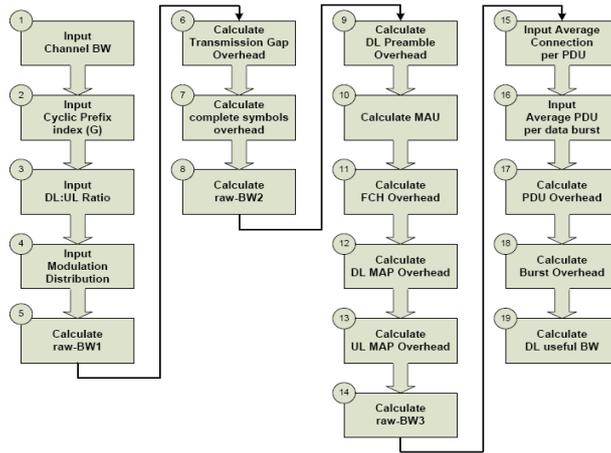
In the second column since,  $T_{DL}$  and  $T_s$  can have variable values based DL:UL ratio and CP index respectively, we need to find out how many complete symbols ( $N_{S-DL}$ ) can be embedded in the downlink sub frame ( $T_{DL}$ ).

$$N_{S-DL} = \lfloor (T_{DL} - T_g) / T_s \rfloor \text{ (eq-2.5)}$$

Where  $T_{DL} = DL / (DL+UL) \times T_f$  and  $T_f = 5\text{mS}$  and  $T_g = 11.4\mu\text{S}$  are fixed values in Mobile WiMAX applications. Note that  $\lfloor \dots \rfloor$  sign stands for the floor function.

To know how much bandwidth is wasted by incomplete ending symbol and calculate the available BW in stage.8 we can use equation below:

$$BW_2 = \lfloor (N_{S-DL} \times T_s) / T_{DL} \rfloor \times BW_1$$



### VIII. DL PREAMBLE

The first symbol in the DL sub frame is dedicated to introduction which does not carry any data to the subscribers and is used for synchronization purposes. So we need to remove this extra symbol from our useful DL bandwidth as mentioned in stage.9:

$$BW_{3.1} = (N_{S-DL} - 1) \times BW_2$$

### IX. MAU

Minimum Allocation Unit submits to the smallest two-dimensional quantum of frequency and time that can be allocated for sending data across the channel. When it comes to applications that need to send only few amount data the packets can be as small as MAU. This concept makes OFDM technology highly granular and helps the system to reduce the amount of bandwidth wasted in sending small packets. (eq-2.8) reveals how the MAU can be calculated in bytes:

$$MAU = [ (N_C \times OCR) / N_{Sub-CH} ]$$

Where  $N_C$  the coded block size in bytes and OCR is the coding rate of the most robust in use modulation scheme, here 64-QAM as the worst case, and  $N_{Sub-CH}$  is the number of sub-channels based on the system's channel bandwidth using PUSC permutation.

MAU concept can be used in packet **mismatch errors** as well. In general, Packing and

Fragmentation methods are used to fit the size of packets to be sent to the available MAU. However there can be cases where the amount of data to be sent in a burst just spills over a MAU boundary. In these cases nearly an empty MAU is sent, representing a channel overhead. In our algorithm, we consider a 50% mismatch error to by adding MAU/2 bytes overhead to each of our data burst.

### X. FCH

A Frame Control Header in DL sub frame as described in section 1.3.4. The overhead associated with this signaling message is equal to one MAU. The FCH and other signaling messages like DL and UL MAPs, are sent utilizing the lowest modulation level within the cell (normally BPSK1/2) to make sure that all subscriber stations inside the coverage area can receive it.

### XI. MAP MESSAGES

The subcarriers' mapping must be broadcast to all users whenever the resource allocation changes. Generally, MAP messages are used in the downlink sub frame and introduce a considerable amount of overhead which increases as the number of connecting subscribes raises. So a dynamic algorithm, based on the number of users must be defined to calculate these overheads. To do so, first we will briefly examine the texture of each MAP message and we continue with presenting a relation for their overhead calculation.

### XII. DL-MAP

The downlink map begins with eight Bytes of header information followed by a number of information elements (DL-MAP IE). There is one information element for each active connection using the downlink frame and the map must terminate with an IE marking the end of the map. Each DL-MAP\_IE is at least four Bytes long to include a specific MAC connection (CID) and a burst profile code (DIUC) so that a subscriber station can know whether a DL burst contains traffic destined for it or not. Multiple downlink map IE may point to the

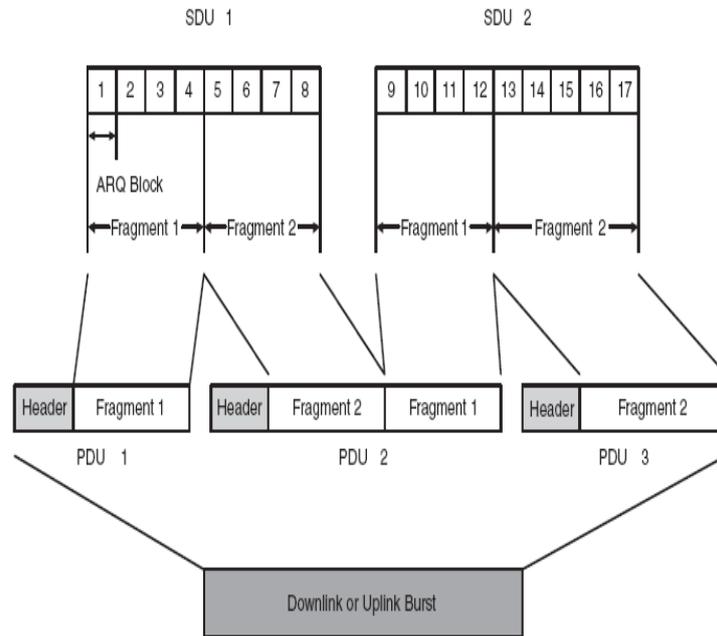
same burst, so that a burst can be shared between one or more subscriber stations. In our capacity estimation algorithm we consider the worst case in which a DL-MAP exists in all DL sub frames being sent by the lowest modulation level. Furthermore, we assume each subscriber station connecting to the sector imposes a 4 byte IE in the Map message. So the overhead would be  $8+N \times 4+4+MAU/2$  bytes considering mismatch error, where  $N$  represents the number of active subscribers.

### XIII. UL-MAP

Practically speaking, an uplink map is essential for subscriber stations to coordinate their uplink access. The uplink map begins with 11 bytes of header information. The same as DL-MAP, each active connection represents an IE in the map message, but this time each with a length of 6 bytes. The ending IE exists in the UL-MAP the same as DL. For the worst case capacity estimation the overhead imposed with UL- MAP would be  $11+N \times 6+MAU/2$  bytes.

In addition to DL and UL map messages, the downlink sub frame may periodically contain

**Channel Descriptor** DL/UL messages. They are intended to present the DL/UL burst profiles' information. Therefore, the amount of overhead they present depends on the number of data bursts in each DL or UL sub frame. Each DL and UL burst occupies 9 and 4 bytes (indicating the profile information) in the DCD and UCD respectively. How often downlink or uplink channel descriptors are sent, and thus their imposed overhead, depends on the channel configuration and how often the linking conditions change. In our algorithm we assume a 100ms sending interval for them. To calculate final DCD or UCD overhead we need to have an idea about the number of data bursts per DL sub frame.



So with the inputs on 15<sup>th</sup> and 16<sup>th</sup> stages we basically allow the algorithm to be customized based on the system's applications. It is done by estimating the number of PDUs and burst in each sub frame based on the number of connecting users ( $N$ ) as follow:

$$N_{PDU} = N / \text{average number of connections per PDU}$$

$$N_{Burst} = N_{PDU} / \text{average number of PDUs per Burst}$$

### XIV. MAC-PDU

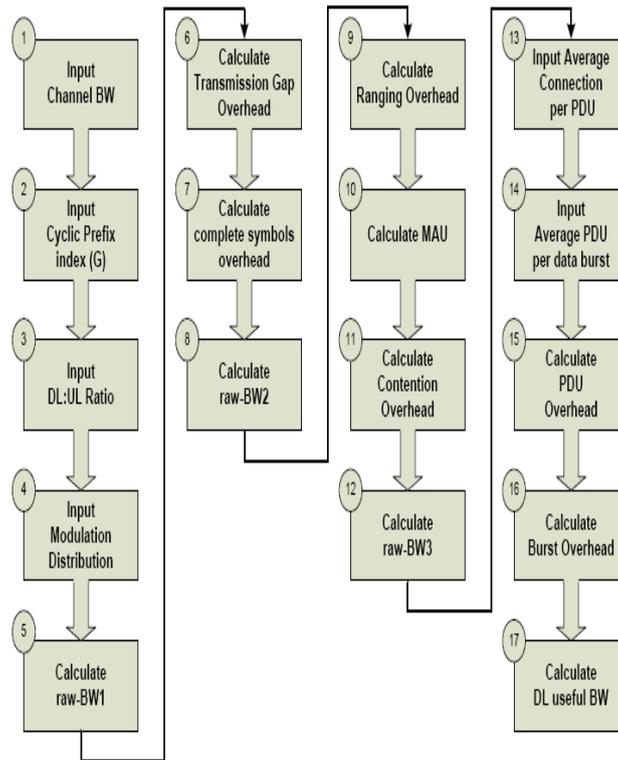
There are some additional information bits in a MAC protocol data unit rather than the data payload. The 6 bytes long Generic Header and 4 bytes CRC checksum are always present in the PDU, while there may be some additional optional sub-headers. Examples of sub-headers are packing and fragmentation that each is 3bytes long. Since these two techniques are mutually exclusive operations we can conservatively estimate that, on average, a 3 bytes long sub-header will be present in each MAC-PDU. So having the average number of PDUs according to the number of connecting users, one can estimate the overall overhead imposed by MAC-PDUs in the downlink sub frame as:  $N_{PDU} \times (6+4+3)$  bytes (eq-2.10)

### XV. DATA BURST

As can be observed from **Figure above** each burst is consisted of one or more MAC-PDUs that are collected under a same burst profile to be transmitted over the downlink sub frame. As PDUs placed in the burst can have variable lengths, the overall size of each burst is variable too. So in addition to the overheads carried by each PDU, there can be a mismatch error while trying to the burst size just spills over a MAU boundary. So as usual a 50% mismatch error should be considered over the  $N_{Burst}$ .

### XVI. UPLINK

As we can see from **Figure below** the uplink practical bandwidth calculation procedure is same like to the downlink in several steps. The main difference is that there is not MAP messages in the uplink sub frame, but as an alternative there is an initial ranging and a contention interval. In extension these differences will be clarified.



Similar to downlink, the uplink practical bandwidth calculation algorithm begins with initial inputs to estimate the raw bandwidth ( $BW_1$ ).

### XVII. RANGING

Mobile WiMAX holds Initial and periodical ranging procedures at the same time as an uplink physical layer process that permits the BS and MS to execute time and power synchronization regarding each other's variety of radio-link parameters through the initial network entry and periodically. The initial ranging occurs only once per connecting user, that can be ignored in capacity estimations. as said by the standard the periodical ranging should be done as a minimum every 2 seconds. These ranging opportunities are allotted on the uplink presumptuous a two-symbol preamble chased by a prearranged sequence, recognized as the ranging code, repeated over two OFDM symbols. Thus generally overhead symbols presented with the ranging interval for the UL over a 5mS TDD frame can be expected as:

$$N_{Ranging} = (5/2000) \times (4/ N_{S-UL}) \quad (eq-2.11)$$

Where  $N_{S-UL}$  is the total number of symbols in the uplink sub frame

### XVIII. CONTENTION

In unlinking, the MS appeals resources by either using a stand-alone bandwidth request MAC-PDU (BRH) or piggybacking bandwidth requests. The BRHs are sent within the contention intervals that are periodically assigned in the UL sub frame. This interval starts with a one-symbol preamble followed by one or

more symbols configured for the resource allocation request. The number of symbols depends on the number of connecting users and the channel's MAU. The size of the allocation should be sufficient to send one BRH for each requesting MS while Each BRH is 6+4=10 Bytes (Header+CRC). In capacity point of view, since an exponentially back-off scheme is used for retransmission of the collided requests, the worst case would be to assume that each connecting MS is sending a BRH in each periodical polling interval. Assuming a 100mS period between each polling interval, the overall overhead symbols of contention interval for the uplink over a 5mS frame can be estimated according to (eq-2.12). Note that the interval between contention allocations is configurable by the operator.

$$N_{S-UL}^{contention} = \frac{(N \times 10 / MAU) + 1}{(5/100) \times N}$$

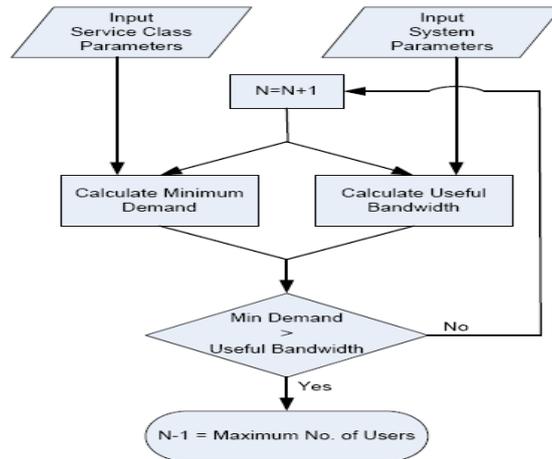
The piggybacking bandwidth request is for the subscribers that have already allocated uplink access by contention or polling process to inform the base station that they require another allocation to send pending data. To do so the subscriber adds a 2 bytes Grant Management (GM) Sub-header in its MAC-PDU. As explained for the downlink, in uplink capacity estimation algorithm two additional inputs are needed to calculate the number of MAC-PDUs and data bursts within the UL sub frame according to the method illustrated in **Figure above**. Having  $N_{PDU}$  and  $N_{Burst}$  you can calculate PDUs' and Bursts' overheads.

### XIX. MAC-PDU

Similar as downlink, each uplink PDU's payload is made with a number of overhead bytes for example GMH, CRC and packing/fragmentation sub-header. The further sub-header in the uplink is 2 bytes GM, as mentioned above, to perform piggybacking bandwidth request. Request collisions are handled in the common exponential back-off fashion therefore in the nastiest case we can suppose that each connecting MS is sending GM in each MAC-PDU. In that case the overall overhead bytes forced by PDUs would be:  $N_{PDU} \times (6+4+3+2)$  Bytes.

### XX. DATA BURST

Although the 50% mismatch error overhead, in uplink each burst starts with a preamble to synchronize its containing subscribers with the base station. Each preamble occupies one symbol that is modeled to one MAU in our algorithm. Therefore the overhead bytes introduced with each burst are  $MAU \times (1+1/2)$ . Note that these extra bytes are sent as mentioned in the profile of their corresponding burst. Hence it is not far from reality if we assume their transmission parameters are the same as our modulation distribution assumption.



The algorithm can be put into practice in both DL and UL directions, one by one. First we start with one single user trying to connect to the sector. In the second step, two types of input, the Minimum Demand data-rate and the available bandwidth are to be determined in each direction. These two values are evaluated to check if the load in both DL and UL can be served. If there is enough bandwidth available the number of subscriber's increases by one and the channel availability process is being rechecked by comparing the additional data-rate that this extra user will demand by the overhead that it imposes on the useful bandwidth. Whenever the minimum demanded data-rate exceeds the amount of available BW in each direction, the algorithm stops and introduces the maximum number of subscribers that can be simultaneously served by the sector with already entered parameters.

The complete algorithm is implemented in a Matlab code. Different cases based on different service and system parameters are investigated and numerical and graphical results for each case are discussed. The Matlab-Code is consisted of a main function that contains two sub-functions for the practical bandwidth calculations in DL and UL directions.

The user is asked to enter two groups of input parameters; Service Class Parameters and System Parameters correspondingly. The output of the program is consisted of the maximum number of supportable users for the formerly specified sector and a number of related numerical values enclosed with a visualization graph that illustrates the trend diagram of the DL/UL capacity and demand. The user interface of the M-Code (Matlab Command Window and resulting Figure) is illustrated. Three different case-studies are studied base on different system parameters and traffic services. It has been tried to choose the input values according to the practical situations. The case-studies are arranged in an order to arrive at an optimized conclusion, while using trail and error base on the presented M-code. To provide the user with a good insight of the code's functionality, additional notes and marks are included in the report and some comparisons are made for the presented case-studies. The input and output data are specified in the data-sheet (Matlab Command Window). The input parameters are highlighted in yellow and their corresponding values are indicated with the sign (red), while the output data are highlighted in green and their values are indicated with the sign (red).

**Case 1:**

**APPLICATION DISTRIBUTION**

```
-----
APPLICATION          DATA-RATE WEIGHT
Interactive gaming    50kbps 25%
VoIP and Video Conf. 32kbps 10%
Streaming Media      64kbps 12.5%
Web Browsing + Email nominal 30%+2.5%
Media Content Downloading BE 20%
-----
```

--->> **SERVICE CLASS PARAMETER (RESIDENTIAL/BUSINESS/OSR) <<---**

```
Enter the DATA-RATE for RESIDENTIAL Class Subscribers(kbps) :512
Enter the PERCENTAGE of RESIDENTIAL Class Subscribers(%) :60
Enter the CONTENTION RATIO for RESIDENTIAL Class Subscribers :30
Enter the DATA-RATE for BUSINESS Class Subscribers(kbps) :2000
The PERCENTAGE of BUSINESS Class Subscribers is :40%
Enter the CONTENTION RATIO for BUSINESS Class Subscribers :10
Enter the OVER SUBSCRIPTION RATIO (OSR) :50
```

**MODULATION DISTRIBUTION**

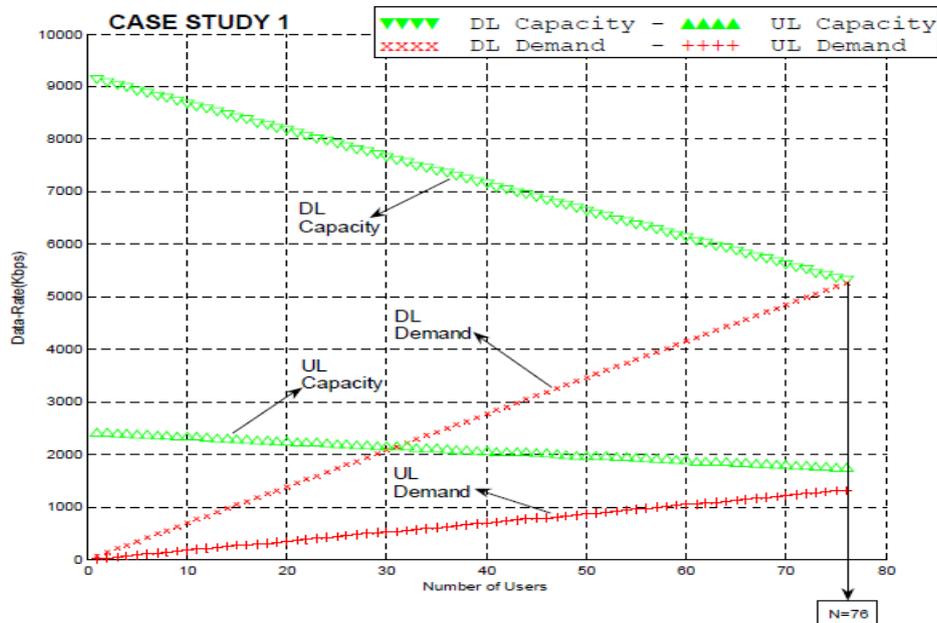
```
-----
MOD-TYPE OCR WEIGHT k
64QAM 3/4 40% 6
64QAM 2/3 40% 6
16QAM 3/4 5% 4
16QAM 1/2 5% 4
QPSK 3/4 2.5% 2
QPSK 1/2 2.5% 2
BPSK 1/2 5% 1
-----
```

--->> **SYSTEM PARAMETERS <<---**

```
Enter the channel bandwidth (5/10 MHz) :5
Enter the CYCLIC PREFIX RATE (4/8/16/32):8
DL:UL SUBFRAME RATIO - Enter DL portion :3
DL:UL SUBFRAME RATIO - Enter UL portion :1
Enter the DL/UL TRAFFIC RATIO :4
Enter the average number of connections per PDU :2
Enter the average number of PDUs per data burst :2
-----
```

```
-----
The PEAK data-rate in the <DL> is 9147.62 kbps
The PEAK data-rate in the <UL> is 2396.86 kbps
Maximally, 76 simultaneous users are supportable with this sector
5268.62 kbps is the MIN-DEMAND in the <DL> for 76 subscribers
1317.16 kbps is the MIN-DEMAND in the <UL> for 76 subscribers
-----
```

5327.19 kbps is AVAILABLE BW in the <DL> for 76 subscribers  
 1733.89 kbps is AVAILABLE BW in the <UL> for 76 subscribers  
 The achieved OSR=48.0691 for 76 simultaneous subscribers



76 users be able to supported with the specified sector. Where as according to the output data the limitation of the algorithm is concerned with the Downlink capacity. In other way you can say that, the sector with the specified parameters be capable to support 76 mixed traffic users based on the modulation and application distribution suppositions and the traffic demand, while the bandwidth demand of the 77<sup>th</sup> user can not be afforded in the DL direction.

The peak available data-rate in DL is 9147.62 kbps that decreases to 5327.19 kbps as the number of users reaches to 76. The minimum demand data rate for 76 simultaneously connecting users is 5268.62 kbps that can be fulfilled with the available bandwidth in the DL.

**Case 2:**

MATLAB COMMAND WINDOW  
 APPLICATION DISTRIBUTION

```

APPLICATION          DATA-RATE WEIGHT
Interactive gaming    50kbps  25%
VoIP and Video Conf. 32kbps  10%
Streaming Media      64kbps  12.5%
Web Browsing + Email nominal 30%+2.5%
Media Content Downloading BE 20%
    
```

--->> SERVICE CLASS PARAMETERS (RESIDENTIAL/BUSINESS/OSR) <<---

```

Enter the DATA-RATE for RESIDENTIAL Class Subscribers(kbps) :1000
Enter the PERCENTAGE of RESIDENTIAL Class Subscribers(%) : 60
Enter the CONTENTION RATIO for RESIDENTIAL Class Subscribers : 20
Enter the DATA-RATE for BUSINESS Class Subscribers(kbps) : 3000
The PERCENTAGE of BUSINESS Class Subscribers is : 40%
Enter the CONTENTION RATIO for BUSINESS Class Subscribers : 10
Enter the OVER SUBSCRIPTION RATIO(OSR) :65
    
```

MODULATION DISTRIBUTION

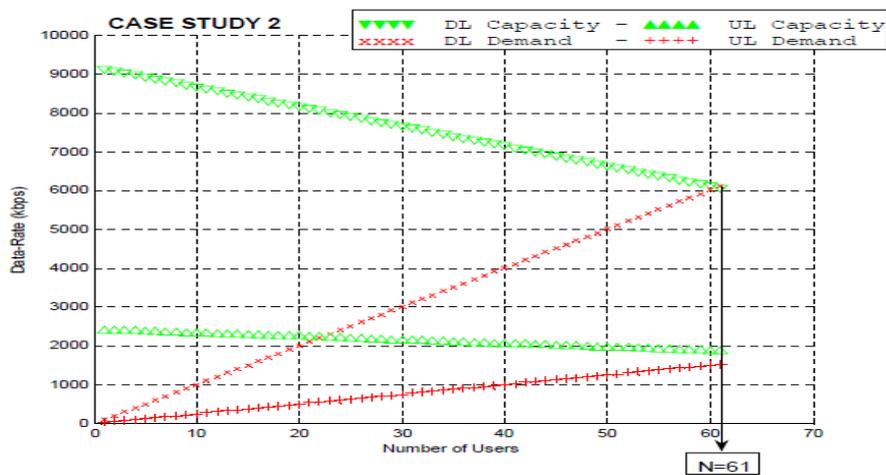
```

MOD-TYPE OCR WEIGHT k
64QAM 3/4 40% 6
64QAM 2/3 40% 6
    
```

16QAM 3/4 5% 4  
 16QAM 1/2 5% 4  
 QPSK 3/4 2.5% 2  
 QPSK 1/2 2.5% 2  
 BPSK 1/2 5% 1

-----  
 --->> SYSTEM PARAMETERS <<---  
 Enter the channel bandwidth (5/10 MHz): 5  
 Enter the CYCLIC PREFIX RATE (4/8/16/32):8  
 DL:UL SUBFRAME RATIO - Enter DL portion :3  
 DL:UL SUBFRAME RATIO - Enter UL portion :1  
 Enter the DL/UL TRAFFIC RATIO : 4  
 Enter the average number of connections per PDU :2  
 Enter the average number of PDUs per data burst :2  
 -----

The PEAK data-rate in the <DL> is 9147.62 kbps  
 The PEAK data-rate in the <UL> is 2396.86 kbps  
 Maximally, 61 simultaneous users are supportable with this sector  
 6124.77 kbps is the MIN-DEMAND in the <DL> for 61 subscribers  
 1531.19 kbps is the MIN-DEMAND in the <UL> for 61 subscribers  
 6084.8 kbps is AVAILABLE BW in the <DL> for 61 simultaneous subscribers  
 1854.5 kbps is AVAILABLE BW in the <UL> for 61 simultaneous subscribers  
 The achieved **OSR=62.7233** for 61 simultaneous subscribers



In Case-Study-2, the system parameters are kept the same as Case-Study-1. Only the Service class parameters are changed as indicated in the data sheet with the red rectangle. Since in the new test, the subscribers in both residential and business service classes are assigned higher data-rate values, the number of users that a sector with the same specified system parameters as Case-Study-1 can serve is expected to be less. As Case-Study-2 proves, the aforesaid sector can support the new demand only for 61 subscribers. Again the system is limited in downlink direction. Note that since the system parameters in two experiments are the same, the peak data-rates are identical.

Another notable result while comparing test 1 and 2 is the OSR value. As can be seen the achieved OSR value in Case-Study-1 is less than the corresponding value in the Case-Study-2. This is while the maximum amount of supportable users in the first test is even greater than the subscribers in second test. The fact is that the OSR value is related to the portion of the offering data-rate that can be served with the lowest modulation scheme (BPSK). Since test 2 is offering more data-rate per user, it suffers more over subscription ratio. If the desired OSR value in the Case-Study-2 would be the same as Case-Study-1, this value could be the limitation factor for the maximum number of users.

**Case study 3:**

MATLAB COMMAND WINDOW  
 APPLICATION DISTRIBUTION

-----  
 APPLICATION                      DATA-RATE WEIGHT

Interactive gaming            50kbps 25%  
 VoIP and Video Conf.        32kbps 10%  
 Streaming Media            64kbps 12.5%  
 Web Browsing + Email       nominal 30%+2.5%  
 Media Content Downloading   BE 20%

--->> SERVICE CLASS PARAMETERS(RESIDENTIAL/BUSINESS/OSR) <<---

Enter the DATA-RATE for RESIDENTIAL Class Subscribers(kbps) :1000  
 Enter the PERCENTAGE of RESIDENTIAL Class Subscribers(%) : 60  
 Enter the CONTENTION RATIO for RESIDENTIAL Class Subscribers : 20  
 Enter the DATA-RATE for BUSINESS Class Subscribers(kbps) : 3000  
 The PERCENTAGE of BUSINESS Class Subscribers is : 40%  
 Enter the CONTENTION RATIO for BUSINESS Class Subscribers : 10  
 Enter the OVER SUBSCRIPTION RATIO(OSR) :65

MODULATION DISTRIBUTION

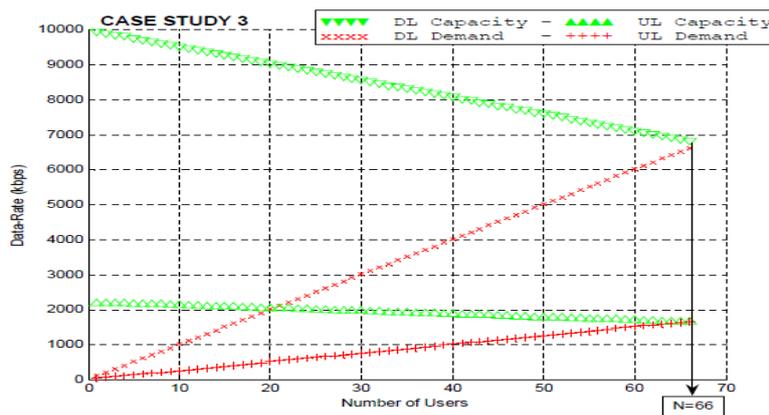
MOD-TYPE OCR WEIGHT k

64QAM 3/4 40% 6  
 64QAM 2/3 40% 6  
 16QAM 3/4 5% 4  
 16QAM 1/2 5% 4  
 QPSK 3/4 2.5% 2  
 QPSK 1/2 2.5% 2  
 BPSK 1/2 5% 1

--->> SYSTEM PARAMETERS <<---

Enter the channel bandwidth (5/10 MHz): 5  
 Enter the CYCLIC PREFIX RATE (4/8/16/32):16  
 DL:UL SUBFRAME RATIO - Enter DL portion :7  
 DL:UL SUBFRAME RATIO - Enter UL portion :2  
 Enter the DL/UL TRAFFIC RATIO : 4  
 Enter the average number of connections per PDU :2  
 Enter the average number of PDUs per data burst :2

The PEAK data-rate in the <DL> is 9969.97 kbps  
 The PEAK data-rate in the <UL> is 2194.69 kbps  
 Maximally, 66 simultaneous users are supportable with this sector  
 6626.8 kbps is the MIN-DEMAND in the <DL> for 66 subscribers  
 1656.7 kbps is the MIN-DEMAND in the <UL> for 66 subscribers  
 6844.18 kbps is AVAILABLE BW in the <DL> for 66 subscribers  
 1648.69 kbps is AVAILABLE BW in the <UL> for 66 subscribers  
 The achieved OSR=64.0943 for 66 simultaneous subscribers



In Case-Staudy-3, this time the service class parameters are kept the same as Case-Staudy-2, while it has been tried to change the system parameters in an efficient way in order to benefit a higher capacity. As it is highlighted in the data sheet for Case-Staudy-3, the system is again based on 5MHz channel width and with DL/UL Traffic Ratio=4. Basically, in this test we try to manipulate the configurable system parameters in order to maximize the number of users that can be covered with the sector. One of these parameters is DL:UL Ratio. As in former test the limitation was concerned with the downlink, by assigning a greater portion to the DL-subframe we can increase the total capacity. Thus a DL:UL Ratio of 7:2 is assigned in Case-Staudy-3 instead of the former value of 3:1 in Case-Staudy-2. Furthermore, by choosing a higher level Cyclic Prefix Index we can achieve less overhead and hence greater throughput. Assigning a CP=16 in Case-Staudy-3 implies that 1/16 of the useful symbol duration is repeated at the beginning of each symbol. Thus the system suffers less overhead when compared with Case-Staudy-2 where CP=8.

Note that the cyclic prefix is used to eliminate the inter symbol interference. Therefore, in new CP-index assignment the channel's delay spread and interference conditionings must be considered. As can be observed in the results, the new system parameters in Case-Staudy-3 introduce a greater peak data-rate in the downlink so that the sector can support more users in this direction. Note that the DL:UL Ratio assignment must be done in an efficient way to provide both directions with the required capacity. The system based on the new parameters in Case-Study-3 can support 66 subscribers that are 5 more user compared with Case-Staudy-2. Although this time the algorithm limitation is concerned with the uplink, the downlink stream is also efficiently occupied. In other words, in Case-Study-3 the system capacity and demand are matched in an optimized way, as both DL and UL entire capacities are efficiently filled with each direction's traffic demand.

## XXI. CONCLUSION

The greatest advantage of WiMAX over other competitor technologies is the timing. At the moment, Mobile WiMAX is ready to be deployed and to start serving the insatiable demand for wireless broadband, while LTE is at least 2 years away. Although most traditional cellular mobile operators are not backing WiMAX, there are a considerable number of global service providers such as; Clearwire, Sprint and Vodafone, etc, and reputable companies such as; Intel, Dell, Nokia, Siemens, Motorola, NEC and Samsung, etc, who support WiMAX policies. Siavash Alamouti, the CTO of the Intel's Mobile Wireless Group in his last declaration on June 2008 states his views on WiMAX vs LTE as ;  
"Even in its first generation, WiMAX is showing 2-3x performance over today's 3G (HSPA). With the next iteration of the standard, 802.16m, WiMAX will evolve and offer even greater speeds, just as LTE is coming to market. Both WiMAX and LTE have many similarities and both require significant upgrades to existing network equipment and phones – the evolution path from a 3G to 4G network is very similar regardless of an operator's choice of 4G technology. Intel currently has no silicon plans for LTE."

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