Radio Link Analysis for 4G TD- LTE Technology at 2.3 GHz Frequency

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***Abstract*—The Long Term Evolution (LTE) is the latest step in an advancing series of mobile telecommunications systems. In this paper, authors show interest on the link budgeting the information presented here will help readers understand how the budgeting will be done in LTE. This paper provides dimensioning of LTE for particular city. This will provides the number of cell count. Here we tell about a GUI MATLAB System for calculation of no. of resources required to provide services in particular area with optimum cost and better quality.**

***Index Terms*—LTE, Throughput, Radio link Budget Time Division Duplexing, MAPL, Cell count**

I. Introduction

Driving the evolution of wireless broadband technology is user's increasing expectations for speed, bandwidth, and global access. For wireless carriers to achieve greater speeds and pervasive connectedness, their networks need to start behaving more like landline IP-based networks. This line of thinking represents a fundamental shift in perspective from mobile services to broadband connections for users and service providers alike to enter the fourth-generation (4G).Unlike earlier wireless standards, 4G technology is based on TCP/IP, the core protocol of the Internet. TCP/IP enables wireless networks to deliver higher-level services, such as video and multimedia, while supporting the devices and applications of the future. This point of time, there are two technologies which can provides such user experience IEEE's WiMAX and 3GPP LTE. The service provider believes that make LTE offers a number of significant technological and business advantages over WiMAX that make it a superior networking standard. Long Term Evolution (LTE) has been designed to support only packet-switched services. It aims to provide seamless Internet Protocol (IP) connectivity between User Equipment (UE) and the packet data network (PDN), without any disruption to the end user's applications during mobility

The term "Long Term Evolution" encompasses the evolution of the Universal Mobile Telecommunications System (UMTS) radio access through the Evolved UTRAN (E-UTRAN) it is accompanied by an evolution of the non-radio (Core Network) aspects under the term "System Architecture Evolution" (SAE), which includes the Evolved Packet Core (EPC) network.

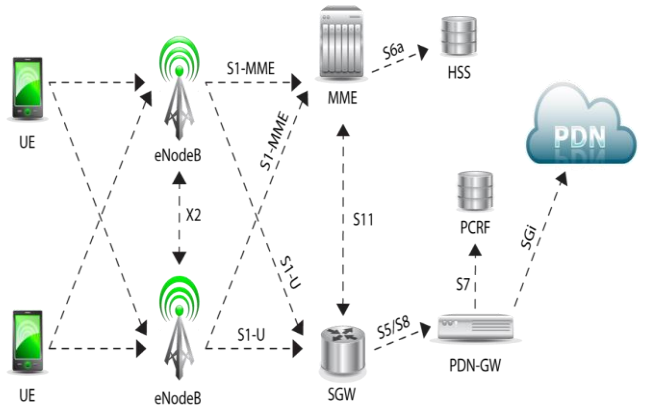

Figure 1: **LTE Architecture and Its Interfaces**

At a high level, the network is comprised of the Core Network (EPC) and the access network E-UTRAN. The Core Network consists of many logical nodes. The core network in LTE is called Evolved Packet Core (EPC) which is responsible for the overall control of the UE and establishment of the bearers. The main logical nodes of the EPC are PDN Gateway (PGW), Serving Gateway (S-GW), Mobility Management Entity (MME), Home Subscriber Server (HSS), Policy Control and Charging Rules Function (PCRF) The access network is made up of essentially just one node, the evolved NodeB (eNodeB), through which Connects UE to the network. Each of these network elements is interconnected by means of interfaces that are standardized in order to allow multi-vendor interoperability. This gives the possibility to source different network elements from different vendors.

II. OBJECTIVES AND APPROACH

This work describes the dimensioning process of 3GPP LTE access network, its models, methods and the tool developed to dimension the network.

The main objectives are listed below:

- To identify the level of throughput for optimum cost and acceptance quality.
- Introduction of LTE features relevant for the dimensioning
- Definition of the basic models for Access Network Dimensioning

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- Coverage Estimation for LTE using 2.3 GHz. frequency
- Network Element Count(cell count) Estimation for any particular area
- Development and description of dimensioning tool.

III. EVOLUTION: 1G AMPS TO 4G LTE

The various communications systems looking in the past revolutionized the way people Communicate, joining together communications and mobility. Evolution of wireless access technologies is about to reach its fourth generation (4G). Looking past, wireless access technologies have followed different evolutionary paths aimed at unified target: performance and efficiency in high mobile environment. The first generation (1G) AMPS has fulfilled the basic mobile voice, while the second generation (2G) GSM (3GPP), CDMA one (3GPP2) has introduced capacity and coverage. This is followed by the third generation (3G), UMTS, WCDMA (3GPP) and EV-DO (3GPP2) which has quest for data at higher speeds to open the gates for truly "mobile broadband" experience, which will be further realized by the fourth generation (4G).

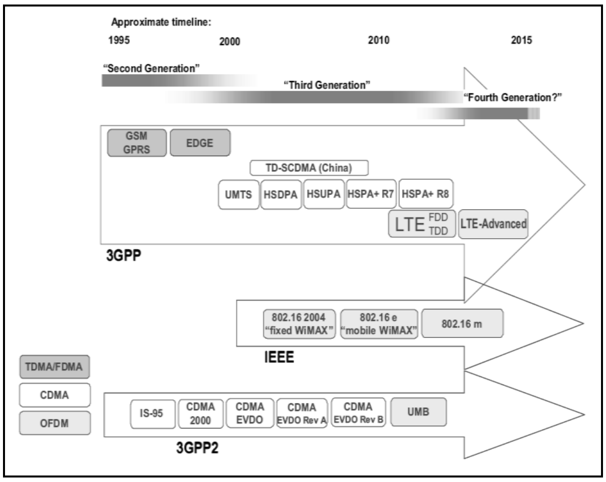

Figure 2: Evolution: 1G AMPS to 4G LTE

IV. KEY FEATURES OF LTE

The 4 G Long Term Evolution has following key feature which make this technology superior than other technologies.

1. Peak Through put: -Peak download rates up to 300 Mbps and upload rates up to 75.Mbps depending on the user equipment category (with 4x4 antennas using 20 MHz of spectrum).

2. Low Latency: -Low data transfer latencies (sub-5ms latency for small IP packets in optimal conditions), lower latencies for handover and connection setup time than with previous radio access technologies.

3. Mobility Support:-Improved support for mobility, exemplified by support for terminals moving at up to 350 km/h (220 mph) or 500 km/h (310 mph) depending on the frequency band.

4. Access Technologies:-OFDMA for the downlink, SC-FDMA for the uplink to conserve power.

5. Duplexing Support:-Support for both FDD and TDD communication systems as well as half-duplex FDD with the same radio access technology

6. Flexible Bandwidths: - 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz

7. Large Cell Size Support:-Support for cell sizes from tens of meters radius (Femto and Pico cells) up to 100 km radius microcells. In the lower frequency bands to be used in rural areas, 5 km is the optimal cell size, 30 km having reasonable performance, and up to 100 km cell sizes supported.

8. Simplified architecture: LTE architecture is FLAT IP Based. The access side of LTE is composed only of eNodeB. Support for inter-operation and co-existence with legacy standards like GSM/EDGE, UMTS and CDMA2000.

V. BENEFITS OF LTE

- Provides a global ecosystem with inherent mobility
- Offers easier access and use with greater security and privacy
- Dramatically improves speed and latency
- Delivers enhanced real-time video and multimedia for a better overall experience
- Enables high-performance mobile computing
- Supports real-time applications due to its low latency
- Creates a platform upon which to build and deploy the products and services of today and those of tomorrow
- Reduces cost per bit through improved spectral efficiency.

VI. TECHNICAL DIFFERENCES BETWEEN LTE AND WiMAX

There are so many number of technical differences exists between LTE and WiMAX. These differences shows that LTE have so many advantages over WiMAX.

Table 1: Differences between LTE and WiMAX

Parameter	LTE	WiMAX
	MIMO	MIMO
Technology	UL- SC-FDMA DL- OFDM	UL-OFDMA DL- OFDM
Peak speeds	DL: 100 Mbps (20 MHz, 2x2 MIMO) UL: 50 Mbps (20 MHz, 1x2)	DL: 46 Mbps UL: 7 Mbps
Average user throughput	5 Mbps–12 Mbps –DL 2 Mbps–5 Mbps - UL	2Mbps–4Mbps –DL 500kbps–1.5 Mbps - UL
One-way air link latency	15ms	50ms
Bandwidth	20 MHz, 15 MHz, 10 MHz, 5 MHz, and <5 MHz	3.5 MHz, 5 MHz, 7 MHz, 8.75 MHz, 10 MHz
Spectrum	various frequencies, 700Mhz	2.3, 2.5, 3.5, 5.8 GHz
Mobility	350 Kmph	120Kmph
Interoperability	Global roaming	Limited international roaming
Backwards compatibility	Connects to legacy 3GPP networks	None; new build out

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VII. LTE DIMENSIONING PROCESS

LTE Dimensioning process starts with the Radio Link Budget Calculations, used to determine the maximum path loss. The result of this step depends upon the propagation models used. The estimated cell size, obtained in this step, leads to the maximum allowed size of the cells. This parameter is used to calculate the number of cells in the area of interest. Thus, a rough estimate of the required number of eNBs is obtained. This paper work focus is on Radio Link Budget, cell coverage estimates and tools and case studies for LTE dimensioning. Figure depicts LTE dimensioning exercise in detail. Coverage Planning is the first step in the process of dimensioning. It gives an estimate of there sources needed to provide service in the deployment area with the given system parameters, without any capacity concern. Therefore, it gives an assessment of the resources needed to cover the area under consideration, so that the transmitters and receivers can listen to each other. In other words, there are no QoS concerns involved in this process. Coverage planning consists of evaluation of DL and UL radio link budgets. The maximum path loss is calculated based on the required SINR level at the receiver.The minimum of the maximum path losses in UL and DL directions is converted into cell radius, by using a propagation model appropriate to the deployment area. Radio Link Budget is the most prominent component of coverage planning exercise

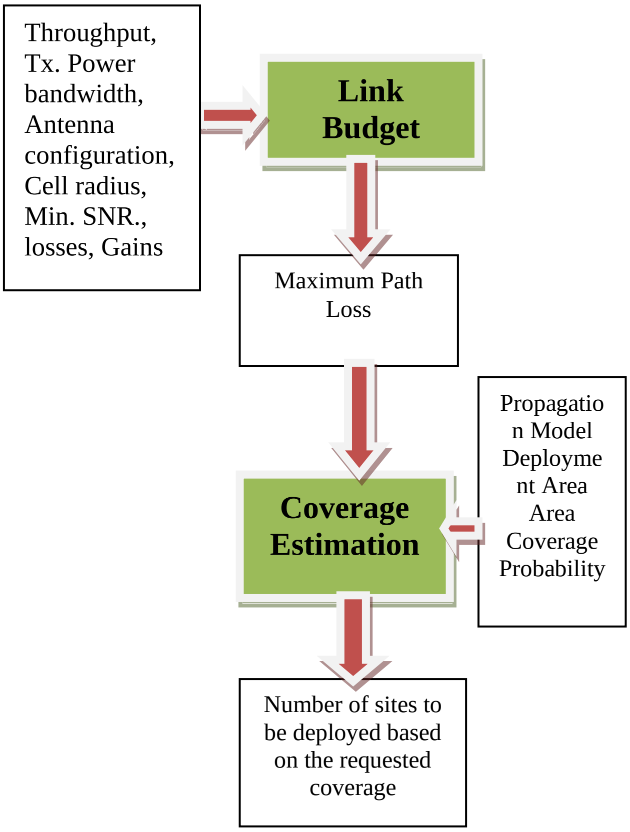

Figure 3: LTE network dimensioning

VIII. RADIO LINK BUDGET

A link budget is the accounting of all of the gains and losses from the transmitter, through the medium (free space, cable, waveguide, fiber, etc.) to the receiver in a telecommunication system. It accounts for the attenuation of the transmitted signal due to propagation, as well as the antenna gains, feed line and miscellaneous losses. Randomly varying channel gains such as fading are taken into account by adding some margin depending on the anticipated severity of its effects.

A **simple link budget equation** looks like this:

Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) − Losses (dB)

The link budget calculations estimate the maximum allowed signal attenuation between the mobile and the base station antenna. The maximum path loss allows the maximum cell range to be estimated with a suitable propagation model. The cell range gives the number of base station sites required to cover the target geographical area.

As we know LTE is a packet network and most of the services are data service. So the Link Budget is for LTE is made on the base of cell edge throughput. The limiting Link is the Uplink Link due the low transmit power of User devices generally 23dBm.

Principle of Link Budget

Maximum allowed path loss (MAPL) = Transmit power - Receiver Sensitivity - Losses - Margins + Gains

Cell radius:

MAPL = Intercept + 10 *Slope *Log10 (Cell Radius)

Cell Radius = 10(MAPL – Intercept) / (10 *Slope)

All above parameters can be used to calculate the Max. Allowable path loss (MAPL).

Next step is to find out the cell radius, to calculate cell radius which have to use propagation model. There are different propagation models like Cost Hata model, Log Normal Propagation model. After getting cell radius we will find out the area covered by a single cell site. If we consider a hexagonal cell site design then area cover by a cell can be calculated by below formula.

Let X be the area covered by a cell site and Y is the area of a city to be covered.

Then no. of cell site Z to cover the city is:

Z = Y / X

Further we can find out the cost of the project by simply multiplying the total cost of one site expenses. Let R is the expense for one cell site then total cost for the project for a city will be

Total cost of project of the city = R * Z

IX. DIMENSIONING TOOL

Matlab GUI is used to dimension the wireless system. In Matlab a system is constructing in which different inputs are given and their corresponding output is analyzed in GUI system. MATLAB is well known for its numerical problem solving power. Traditionally programs written by engineers have very simple interfaces, and often only the author is the one who uses the program once it is completed.

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There are occasions where a more polished user interface, specifically a graphical user interface (GUI) is desired:

- You wish to have a nontechnical, yet computer literate, person use your programs to perform some ongoing data analysis task, etc.
- You wish to share your tool (program(s)) with other members of your work group, but want the interface to be friendly.
- You are writing a utility function for your own use and would like it to be easy to use
- You wish to build an interactive demonstration to best show off a concept or idea to others, e.g., others students etc.
- You or your company is a third-party developer of tools for the MATLAB user community MATLAB flagship software in scientific computing, is extensively used all over the world.
- Particular factors that support the selection of MATLAB are:
- A flexible software structure of MATLAB comprising libraries, models, and programs enables one to integrate different model components in one package conveniently.
- Fast development with MATLAB using powerful calculation and visualization means of the package enables one to expand the software quickly and efficiently without developing any extra programming tools.
- A wide selection of TOOL Boxes, comprehensive collections of predefined functions for solving application-specific problems, is already available with MATLAB and is likely to grow even faster in the future.

The intermediate calculations and detailed formulas are coded. As a result, a user can use the tool without going into details of implementation. Ideally, user is required to look only at the input and output. User can enter all the inputs on box and can then directly go to the output to view the detailed results.

X. WORKING WITH TOOL

1. Choose the Target Uplink Cell Edge Throughput from the drop down list. We have kept three option for this 128 Kbps, 256 Kbps and 512 Kbps. This can be selected based on the types of service to be offered.
2. Now select the TDD configuration to be used. Options are Mode 0, 1 and 2.
3. Select the UE Power, The most of the Handset are of the power class B and support Max Power of 23 dBm, but there are some CPEs (Customer Premises Equipment) which 30 dBm of Power.
4. Choose the Noise figure which can be in range of 3 dB, 3.5dB and 4 dB.
5. Choose the Gain and Loss according to the morphologies.
6. Now press the “Execute 1” you will get the first output as a max allowable path loss.
7. After this choose frequency of operation is my case this will be 2.3 GHz.
8. Choose the height of antenna. For Dense Urban Area we are keeping it 20m, Sub-urban Area we are keeping it as 25m and for Rural Area we kept it as 30m,
9. Receiver height is normally 1.5 m.
10. Put a rough value in cell radius press “Execute 2”, we will get as value next to max allowable path loss.
11. Now we have to make both the value equal , try to change cell radius value to make both the values , When both the values matches for some value of cell radius , that will be the resultant cell radius.
12. Get the radius for all three morphologies.
13. Enter the area for all three morphologies wised urban, Sub-urban area and rural for a city.
14. Press “Execute 3” and we will get the final outs as Cell Sites for each morphologies and Total count for a city.

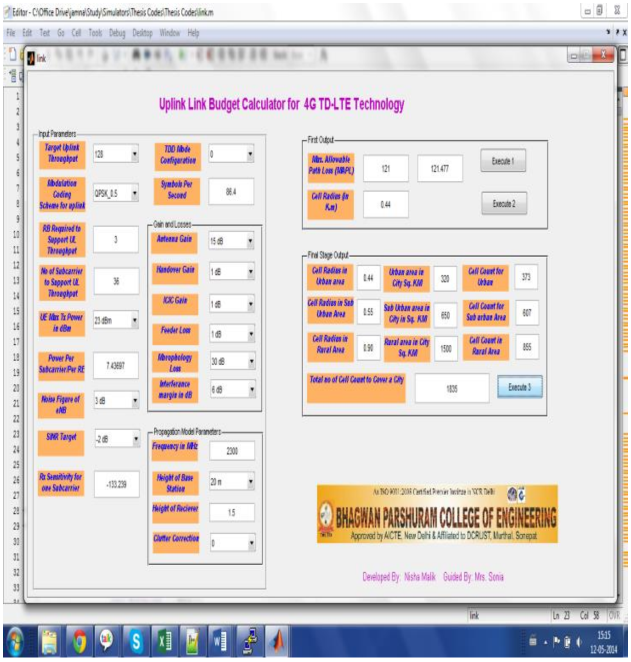

Figure 4: MATLAB Dimensioning Tool

XI. RESULT

Inputs for the simulation

1. Target Uplink Throughputs: 128, 256 and 512 Kbps
2. MCS supported at Cell Edge : QPSK 0.5
3. TDD Mode Configuration = 1 and 2
4. UE Power : 23 dBm
5. Noise Figure =4 dB
6. Target SINR = -4 dB
7. Antenna Directivity Gain =17 dBi
8. Handover Gain and ICIC Gain = 1dB each
9. Morphology Loss = Urban 30 dB, Suburban =25 dB and Rural = 20 dB
10. Interference Margin= 6 dB
11. Frequency =2300 MHz
12. Height of Receiver = 1.5m
13. Clutter Correction= 0 dB for Rural, Suburban and 3 dB for Urban area.

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Result Tables

Target UL Throughput	128 Kbps	256 Kbps	512 Kbps
MAPL (dB)	121-U 126-S 131-R	118-U 123-S 128-R	115-U 120-S 125-R
Cell Radius (km)	.38-U .47-S .59-R	.34-U .47-S .59-R	.3 –U .41-S .52-R
Urban Area in city sq.km	600	600	600
Sub-Urban Area in city in sq.km	900	900	900
Rural Area in city in sq.km	1500	1500	1500
Cell count for urban area	810	906	1026
Cell count for sub urban area	983	983	1127
Cell count for rural area	1305	1305	1480
Total cell count in city	3098	3194	3633

Table 2: Cell Count for TDD Mode 1 configuration

Target UL Throughput	128 Kbps	256 Kbps	512 Kbps
MAPL	118-U 123-S 128-R	115-U 120-S 125-R	112-U 117-S 122-R
Cell Radius	.34-U .44-S .55-R	.3-U .41-S .52-R	.27 –U .36-S .45-R
Urban Area in city sq.km	600	600	600
Sub-Urban Area in city in sq.km	900	900	900
Rural Area in city in sq.km	1500	1500	1500
Cell count for urban area	906	1026	1140
Cell count for sub urban area	983	1127	1283
Cell count for rural area	1305	1480	1711
Total cell count in city	3194	3633	4134

Table 3: Cell count for TDD Mode 2 Configuration

Result Graphs

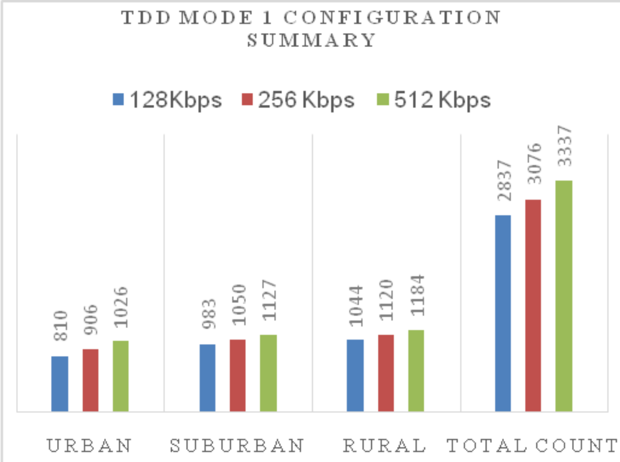

Figure 5: TDD Mode 1 Configuration Cell Summary

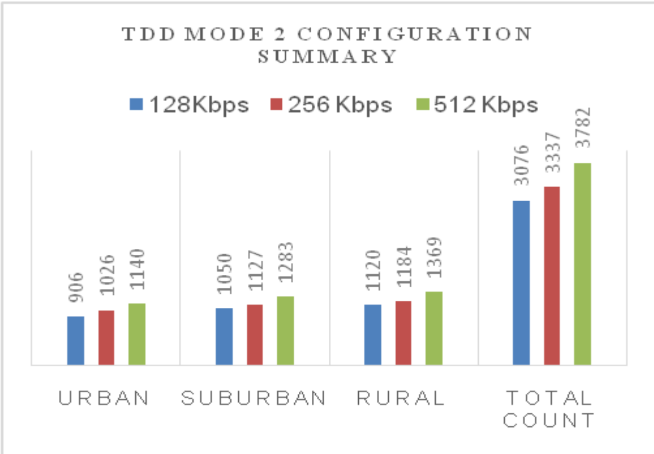

Figure 6: TDD Mode 2 Configuration Cell Summary

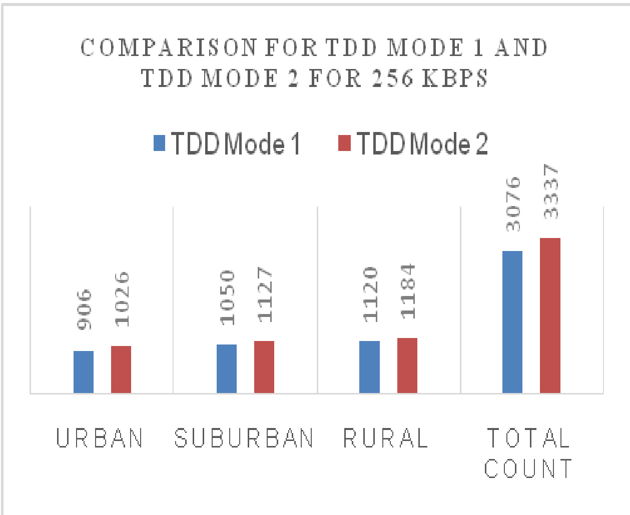

Figure 7: Comparison for TDD Mode 1 and TDD Mode 2 for throughput of 256 Kbps.

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XII. CONCLUSION

We have captured the result for 128 Kbps, 256 Kbps and 512 Kbps for TDD Mode 1 Configuration and TDD Mode 2.

From the results we can conclude the if we use 128 Kbps of cell Target throughput then a city be planned for minimum no of cell sites and for 512 Kbps cell Target throughput then we can plan the maximum cell sites.The choice of cell throughput depend on the operator what is cell throughput they want which is directly impact the quality of network which come with some cost. While making a choice of the Cell target throughput the keep in mind Cost of network as well as the quality of the services. If we decide the 512 Kbps cell Target throughput then we need more cell cite which increase COPEX and well as OPEX for the network. But when we use 128 Kbps Target Cell Edge throughput then we need less number of cell sites, but the quality of the network will be less. So there is a trade-off between the network service quality and network Cost. Then we have a one more choice where we have change scarifies some money and increase the network quality up to some extent, the choice is 256 Kbps in which is lies between both 128 Kbps and 512 Kbps which provides moderate service quality and moderate Network Cost. So network Operator can choose 256 Kbps Cell Target Throughput. Now we have other choice of choosing the TDD mode configuration which can be decided based on the types of services. If a network Operator want to deploy service like VOIP which have need same data rates in both direction i.e. uplink and downlink. So it will better that one can choose a TDD mode configuration which have same percentage of uplink and downlink time and TDD mode will provide this facility which is 50 % downlink and 50 % uplink timing. But in Country like India where most of the services are heavy download where most of the people do movie download song download. If an operator choose TDD mode 1 for heavy download service type network the uplink resources will be wasted. So better to choose the TDD mode 2 which provide more downlink sub frame 60% percentage. If we compare the TDD mode 1 and TDD mode 2 Configuration Cell count for 256 Kbps Cell Target throughput , need more cell sites in TDD mode 2 to cover the same area because the cell radius will be less in TDD mode 2 as compare two TDD mode 1 configuration. So from all the result we can conclude that TDD mode 2 is a better choice for a network operator in a country like India if he want to provide the more download services like web browsing, unlimited download types of services. But this will cost an operator for some cost. An operator can also think on TDD mode configuration 1 if his service profile is symmetric for both uplink and downlink traffic.

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