Analysis of WIMAX/BWA Licensing in India: A real option approach

Sinha, Pankaj and Gupta, Akshay

Faculty of Management Studies, University of Delhi

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Pankaj Sinha and Akshay Gupta

Faculty of Management Studies, University of Delhi

Abstract

Indian Internet and broadband market has experienced very slow growth and limited penetration till now. The introduction of Broadband Wireless Access (BWA) is expected to aid in increasing the penetration of internet and broadband in India. The report sheds light on the guidelines and procedure used in 4G/BWA spectrum auction and presents comparative analysis of the competing technologies, providing the information about suitability of each technology available.

Recently held 4G/ BWA spectrum auction saw enthusiastic participation by the industry and even saw some new entrants in Indian broadband market. Government benefitted by Rs, 385bn that it earned as revenue from the auction of the spectrum and projected it as successful auction. However, the question remains if the auctions were efficient and whether they led to creation of value or will it prove to be burden to the telecom operators and will depress their balance sheet for years to come.

The report uses both traditional valuation methods such as Discounted Cash Flow as well as Real Option approach to answer such questions. Using DCF analysis, the broadband subscribers have been forecasted to grow from present 13.77mn to 544mn by the end of 2025. The wireless subscribers are forecasted to be 70% of the total broadband subscribers after 5 years of roll out as it will be difficult to replace all wireline subscribers with wireless subscribers in India due to the high cost of wireless broadband and new technology. WiMAX is expected to increase its presence with time and reach 90mn subscribers from meager 0.35mn subscribers by 2025. Using industry wide cost of capital as 12.05%, the Net Present Value has been found Rs 221bn aggregate with an IRR of 17.1%. Using Real option approach, the value of license has been calculated as Rs 437bn which is 13.5% more than the spectrum fees paid by the operators. This mismatch, between the auction value and the correct value that should have been discovered by supply-demand dynamics, can be due to limited participants in BWA spectrum auctions and companies such as TATA and Reliance opting out of the auction process midway as well as uncertainty about acceptance of new technology with Indian subscribers.

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1. Introduction

1.1 Country Analysis – India

1.1.1 Introduction

India is the largest democracy in the world with its population touching 1.2 bn[1]. It is also among the fastest growing emerging economy in the world, with a nominal GDP of $1.36 trillion and GDP in terms of PPP of $3.86 trillion, it is 11th largest and 4th largest economy in the world respectively.[1] Even during recent global recession Indian economy has shown considerable resilience and has been able to achieve growth rate of 6.7 percent in 2009-10, which is expected to be followed by growth rate of 8.5 percent[2] in 2010-11, among highest in the world. The resilience comes from the fact that India's economy growth is not majorly dependant on export-oriented sectors like other major economies and the economy is mainly driven by the strong domestic consumption. According to a PwC report titled "The World in 2020", in PPP terms, India's GDP will overtake GDP of Japan in 2011 and of United States by 2045.[3] It further mentions that India's annual economic growth rate is expected to average around 8% and will be the world's fastest growing major economy by 2050, surpassing China.

2009 Rank	Country	GDP at PPP (constant 2009 US $bn)	2050 Rank	Country	GDP at PPP (constant 2009 US $bn)
1	US	14256	1	China	59475
2	China	8888	2	India	43180
3	Japan	4138	3	US	37876
4	India	3752	4	Brazil	9762
5	Germany	2984	5	Japan	7664
6	Russia	2687	6	Russia	7559
7	UK	2257	7	Mexico	6682
8	France	2172	8	Indonesia	6205
9	Brazil	2020	9	Germany	5707
10	Italy	1922	10	UK	5628

Source: PwC estimates

Figure 1: GDP ranking in terms of PPP

[1] International Monetary Fund, http://www.imf.org/, accessed on 9/3/2011
[2] Confederation of Indian Industries, http://www.ciionline.org/Economy.aspx?enc=LqAXY5bXIsb2PzUHQxy2iQ==, accessed on 9/3/2011
[3] PwC Report, "The World in 2050", January 2011

The factors in favor of India have been highlighted as increasingly growth friendly economic policies, significantly younger and faster growing working population, start from a relatively lower level of economic development, changing dependence on outsourcing and more on manufacturing exports due to buildup of strong engineering skills and rising levels of education in the general population and attractive growth of consumers in the form of rapidly growing middle class population.

1.1.2 India's growth drivers

The present factors driving India's growth can be summed as Services, Foreign Direct Investments and Consumption[4]:

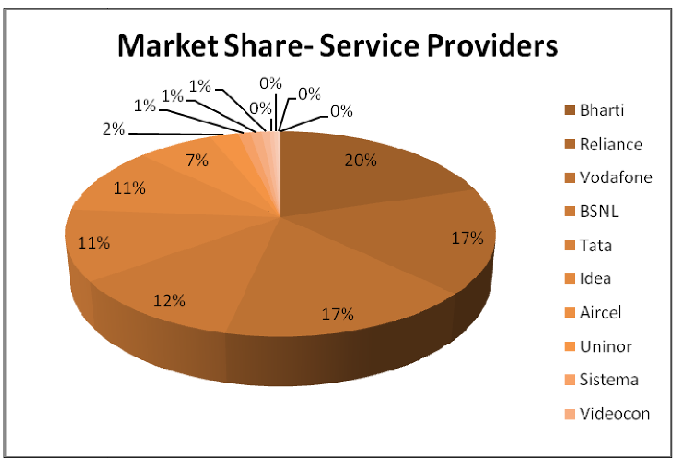
- Services – India has major part of its annual GDP coming from services sector. As per CII, service sector accounted for nearly 60% of the overall growth in India's GDP during the last 10 years. The sector is dynamic and its fastest growing segments are Communications and Banking.
- Foreign Direct Investment – India adopted LPG (Liberalization, Privatization and Globalization) policies starting from 1991-1992 and since then has adopted various initiatives such as opening up of new sectors to FDI, raising caps on FDI in sectors already open for investments as well as simplified and changed procedure for investment in order to attract FDI. Sectors that have attractive largest share of the FDI are power, services, telecommunication, computer software & hardware and housing & real estate
- Consumption – With around 25-30% population as middle class, there has been a spurt in demand for the goods and services, which is expected to only increase in the coming years. India's demographic composition also tilts favorably towards consumption with over 210 million people expected to be in 20-29 years age group by 2015. As a result it is expected to further raise domestic demand for services and products, driven by not only numbers but also by higher incomes, increasingly globalised outlook as well as increasing propensity to spend.

[4] PwC Report, "Mobile Broadband Outlook-2015", 2010

1.2 Industry Analysis – Telecom

1.2.1 Introduction

Indian telecom industry has shown a successful growth story so far growing at a CAGR of approximately 30% since 1995. In wireless, India is world's fastest growing market[5] with CAGR of more than 117% in last 10 years and reaching 752 million mobile phone subscribers by February, 2011[6]. In terms of wireless connection network, India is at second position, just behind China.[7] With a significant contribution of more than 2% of the GDP since 2008-2009, Indian telecom service sector's contribution is expected to rise even further. According to latest TRAI report on subscriptions in India[6], total telephone subscriber base has reached 787.28 million by Dec-2010 an increase of 22.62 million compared to Nov-2010. Indian telecom industry is highly competitive at present with over 10 service providers vying for the pie. This has ensured intense competition and continuously falling ARPU with the introduction of innovative schemes such as Re 20 per minute calling rates, Re30 per month for unlimited SMSes etc, all of which makes the rates lowest in the world.



Source: TRAI

Figure 2: Service provider - Market share

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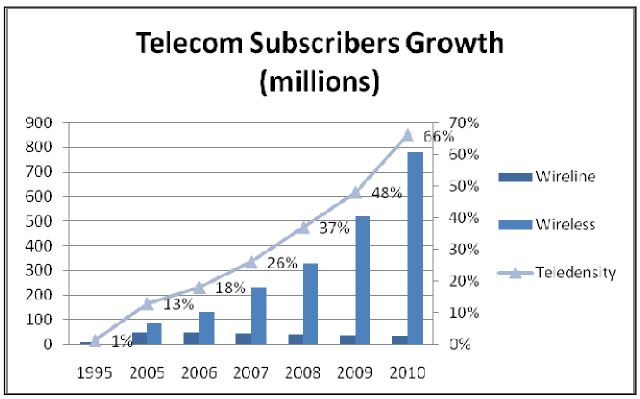
[5] http://www.ibef.org/industry/telecommunications.aspx, accessed on 9/3/2011

[6] TRAI December Report, http://www.trai.gov.in/WriteReadData/trai/upload/PressReleases/798/prerdiv9feb11.pdf, accessed on 1/3/2011

[7] http://indiabudget.nic.in/es2008-09/infra.htm, accessed on 9/3/2011

1.2.2 Key growth driver - Mobile services

95.5% of the subscribers are wireless compared to 4.5% wireline subscribers, with increasing percentages going in favor of wireless. Overall Tele-density reached 66.16% in Dec-2010, an increase from 64.34% in Nov-2010 with overall urban and rural tele-densities being 147.88% and 31.18% respectively. This constitutes wireless tele-density of 63.22% with urban and rural tele-densities being 140.53% and 30.11% respectively, wireline tele-density of 2.95% with urban and rural tele-densities being 7.35% and 1.07% respectively and broadband subscription of 10.92 Million in Dec-2010 with an increase from 10.71 Million in Nov-2010. According to Informa Telecoms & Media's updated forecasts[8], mobile subscribers in India will exceed 1.16 billion by the end of 2013, making it the world's largest mobile market surpassing China. This will be achieved on basis of CAGR of more than 128% expected since end of 2009.



Source: TRAI

Figure 3: Telecom subscribers growth

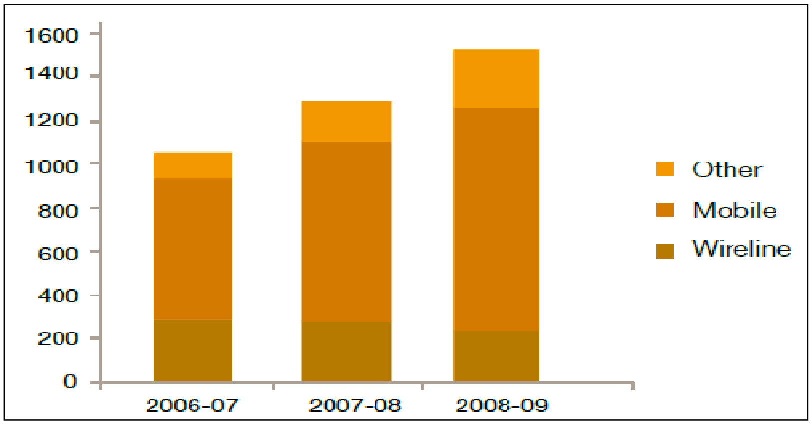
1.2.3 Telecom services revenues

India's telecom services industry revenues are forecasted to rise from Rs. 1,13,000 crore in 2008-09 (growing at CAGR of 20 percent) to about Rs. 344,921 crore (US$76.57 billion) by 2012 with a rate of growth of around 26%, which will lead to generation of employment opportunities for about 10 million people during the same period.[9] The sector will create this employment for 2.8

[8] http://www.informatm.com/itmgcontent/icoms/s/press-releases/20017778395.html, accessed on 9/3/2011

[9] http://economictimes.indiatimes.com/news/news-by-industry/telecom/Indian-telecom-market-to-be-at-Rs-344921-crore-by-2012/articleshow/2563062.cms, accessed on 9/3/2011

million people directly and for 7 million indirectly. Contribution to the revenue has been mainly form mobile services (up to 90%) with decreasing contribution from the wireline not only in percentage but also absolute terms. Services such as Long Distance (National and International), and VSAT etc have also shown increase over the years.

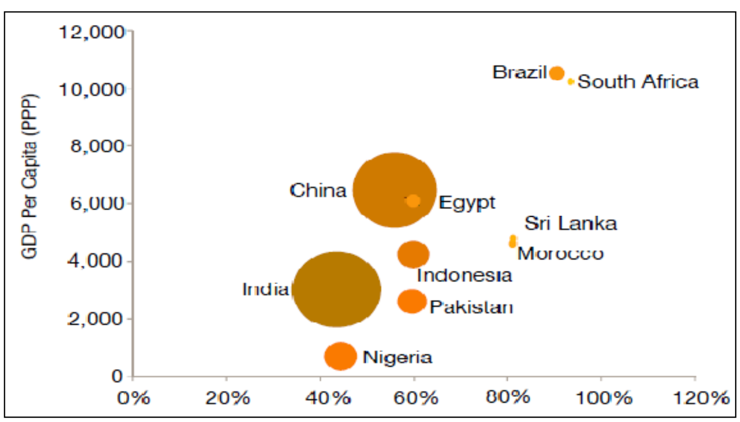


Source: PwC Report/ TRAI

Figure 4: Telecom Services Revenue (Rs '00 crore)

1.2.4 Teledensity - International comparison

A comparison of India's telecom industry with other developing countries shows huge untapped population when compared to countries with similar GDP per capita (in PPP terms). In absolute numbers nearly 500 million population is still without a connection and with increasing penetration in rural areas representing about 70% of the population, this market is waiting to be tapped.

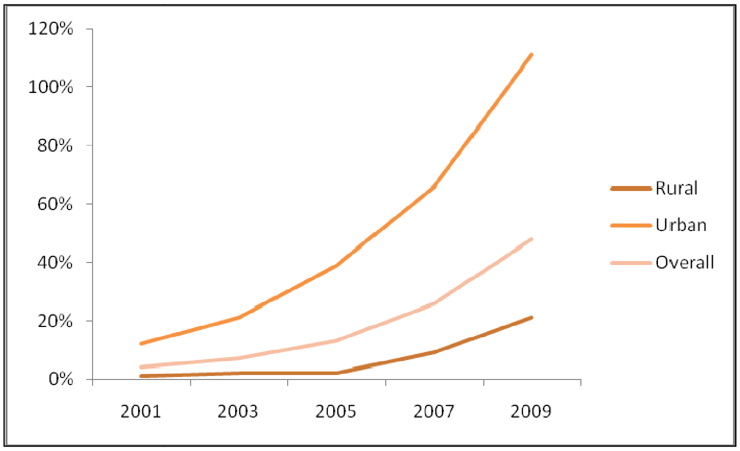


Source: PwC Report

Figure 5: International precedent - Mobile teledensity

1.2.5 Teledensity – Indian scenario

The growth in mobile tele-density is due to exponential growth in last 5 years in both rural as well as urban areas with urban areas leading above 100% tele-density and rural areas lingering around 21% only. Considering that most of the unserved 500 million strong population is in rural areas (combined with saturation levels reached in Urban areas) and with ability to pay moderate to low charges, time is not far when intense competition will drove operators to look for further subscriber growth in rural areas only.[4]

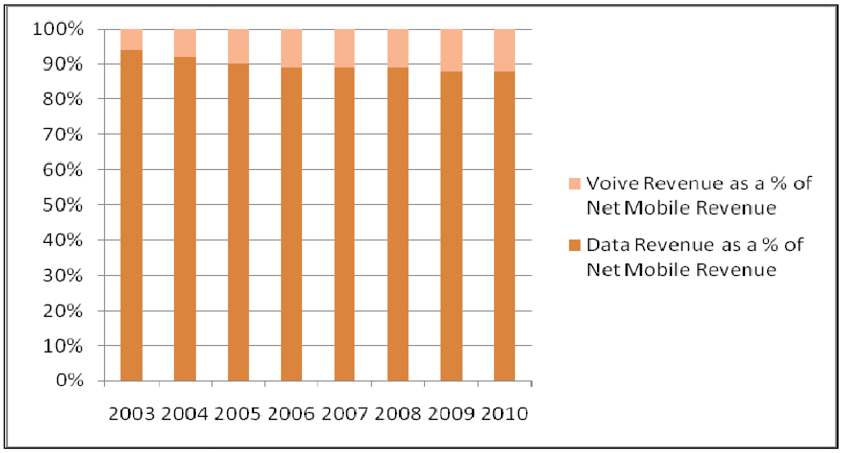


Source: TRAI

Figure 6: Teledensity

1.2.6 Telecom – Data revenue share

Along with the steady increase in subscribers, another trend that has been seen is falling ARPU due to mainly decrease in tariff accompanied with decrease in marginal addition of subscribers. As mentioned before, due to intense competition which has necessitated innovation in the industry has led to significant lowering of the ARPUs over the time. This has in turn necessitated for operators to push Value Added Services (VAS) and other Data Services in order to keep profit margins from falling further. With time Indian consumers are also becoming more savvy and thus these special services can be instrumental in differentiating between companies in the long run. Data revenue has been stagnant at 11-12% for last few years.

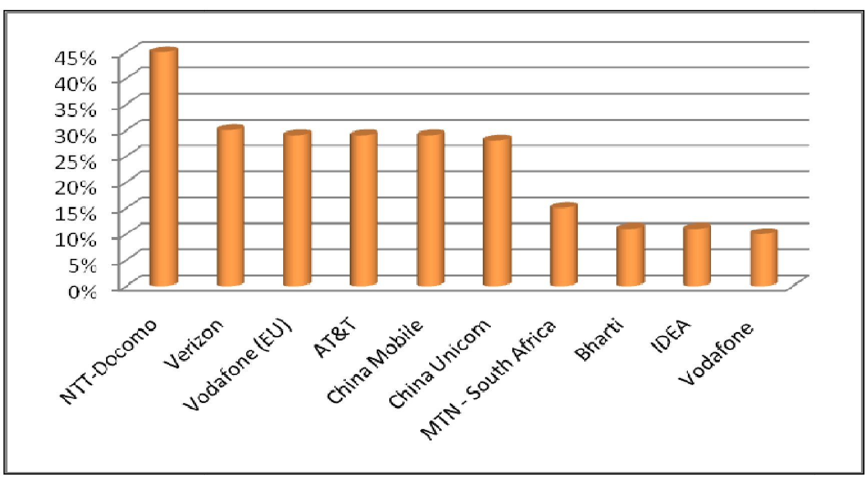


Source: CMIE Database[10]

Figure 7: Data revenue share: Indian GSM Industry

1.2.7 Non-voice revenue – International comparison

When compared to other major economies and their pattern of usage, it can be clearly seen that as population gets exposed to technology, with time the movement is towards more data usage and lesser percentage of voice. This change in percentage of reveue in favor of data comes with more and more use of data applications and in turn leads to increase in ARPU. A similar trend is expected to come in India and the data revenue percentage in overall revenue should increase further.



Source: Reliance report[15]

Figure 8: Non voice revenue mix (%)

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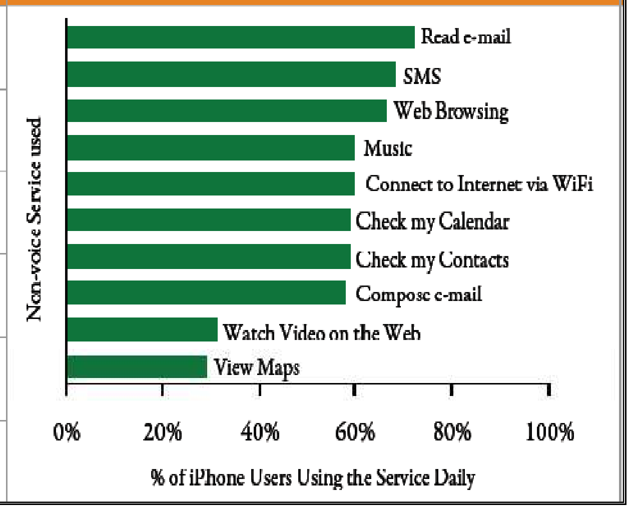
[10] CMIE Database, accessed on 9/3/2011

1.2.8 Data adoption and usage

At present although the revenue from data has been nearly same over the past 4-5 years, the pattern of usage has been changing in favor of the non-SMS data services. According to PwC analysis, currently non-SMS data usage in India is primarily from music related services (such as caller tunes, ringtones and music downloads etc), voice mail services, Multimedia messaging services, data application such as Blackberry, itemized billing, m-commerce applications and download on content applications. Another report by BDA/FICCI sheds light on the usage pattern of smart phone users and overall mobile users in India as shown below:

Activity	iPhone Users	Smartphone Users	All Users[13]
Any news or info via browser	85%	58%	13%
Accessed Web search	59%	37%	6%
Watched mobile TV and/or video	31%	14%	5%
Watched on demand video or TV programming	21%	7%	1%
Accessed Social networking or Blog	50%	19%	4%
Listened to music on mobile phone	74%	28%	7%



Source: FICCI report

Figure 9: Data service adoption and usage

1.2.9 Data application usage pattern

The type of applications used by internet users on mobile differs in developing countries when compared to developed nations. As shown below, in countries such as US and Europe, the main usage is of email services followed by search and news/politics and then sports whereas in countries such as China and India, entertainment, games and music takes more percentage usage. This will be instrumental in type of applications that can be provided in future and as applications used in developing countries are more data intensive and thus it will suit easy adoption of 3G/4G technologies in future and will be a key driving factor.

	US	Europe	China	India	Brazil	Russia
Top 5 website categories (% of mobile internet users)	Email (65%)	Email (46%)	Entertainment (55%)	Games (38%)	Email (57%)	Entertainment (55%)
	Weather (41%)	Search (25%)	Games (36%)	Email (33%)	Music (27%)	Search (29%)
	Search (29%)	News/Politics (26%)	Music (31%)	Entertainment (55%)	Entertainment (55%)	Email (24%)
	News/Politics (26%)	Weather (24%)	News/Politics (26%)	Music (18%)	Games (18%)	Music (24%)
	City Guides/ Maps (24%)	Sports (22%)	Business / Finance (18%)	Sports (15%)	Movies (12%)	Games (24%)

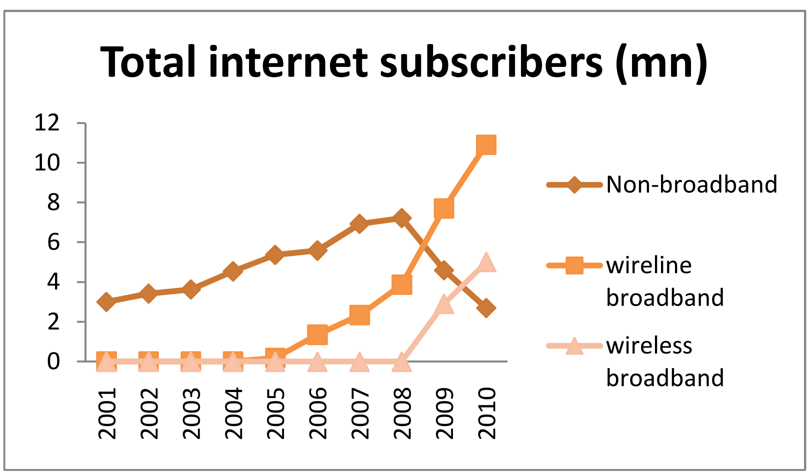
Source: FICCI report

Figure 10: Application usage pattern

2. Broadband – Next driver of growth

2.1 Present scenario

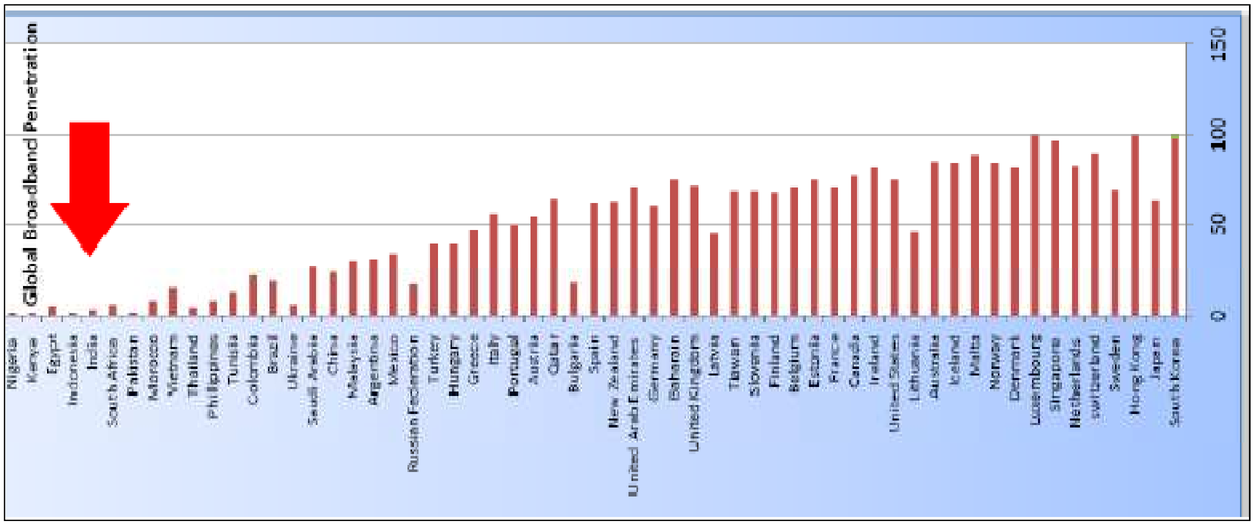
India has very low broadband penetration at present. This is due to the wired infrastructure that cannot afford broadband speed in most of the places especially in rural areas and tier 2/3 cities and thus putting an impediment to the process of providing access through broadband. Since 2005 when wireline broadband connections were made available in India, only 10.9 million subscribers have been added so far which looks insignificant compared to nearly 23 million new mobile subscribers added from November to December 2010.



Source: CMIE database/ TRAI

Figure 11: Internet subscriber's breakup

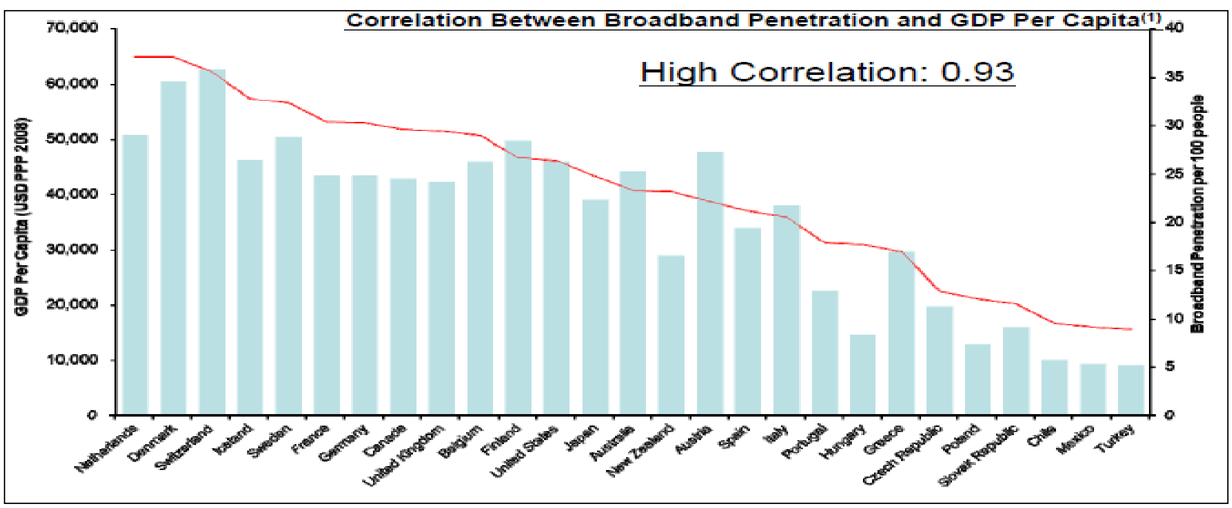
As of March 2010, India had 15.9 million broadband subscribers which included 10.9 million wireline broadband subscribers and 5 million wireless subscribers (mainly TATA and MTNL subscribers using un-licensed spectrum). This is far less than the target of 20 million set by Indian government for the broadband users. Thus Indian market with 66.6% mobile penetration is penetrated even less than 1% in terms of broadband and thus presents a huge market untapped.



Source: Reliance report[15]

Figure 12: Global broadband penetration

The Indian broadband scenario at present is nearly same as it was there in case of the cellular voice by 1995, which is India ranks almost at the bottom with less than 1% penetration. It is expected that with growth in GDP over next decade, the broadband penetration will increase tremendously as seen in other countries.



Source: Reliance report[15]

Figure 13: Correlation between Broadband penetration and GDP per capita

2.2 Present problems

According to PwC analysis the main reasons for this under-penetration are:

1) Low Personal Computers penetration along with limitations in terms of the wireline infrastructure
2) Technical limitations such as right of way challenges and relatively high tariffs
3) The existing infrastructure is mainly limited to urban and semi-urban areas with very less presence in rural
4) Further, the existing wireline infrastructure cannot be used for high speed broadband
5) According to present rules, local loop unbundling cannot be done that would have enabled new payers to use the already present infrastructure

All this has limited the growth of the broadband services. Even though around 20% of the existing mobile users have handset capable of accessing internet but the access has been restricted due to lack of high speed using the existing technologies in wireless namely EDGE, CDMA 1X and GPRS technologies. Recently CDMA providers have launched EVDO technology to provide wireless broadband access.

2.3 Future growth drivers

According the PwC analysis, there are numerous drivers that will be critical in order to reach the expected subscriber base for the broadband that will make the 4G auction affordable to the telecom providers as mentioned below:

- **Demographic Profile**: India's population in the 20 – 29 age group is expected to reach above 210 million by 2015. This will have direct implication on the change in the taste and preference of the general population and the propensity to try the latest and enhanced services as provided by 4G technology should improve and this will in turn make them early adopters of the technology thus expected to drive the 4G market.

- **Quality of Service (QoS)**: Increase demand for streaming videos, online games, improved applications and high speed internet will demand better quality of service than is possible at present. The quality can be only improved by better density of the towers, and better coverage, all of which will depend in turn on the density of the subscribers per base station

- **Applications and Content**: With falling ARPU and services being given at present becoming more or less a commodity, applications are expected to be the real differentiator between operators and the quality and variation in applications will depend on the capabilities that can be provided by 4G

- **Access Device**: The adoption will also depend on the switching costs from DSL/ cable to wireless using 4G technology as well as backward compatibility. The technology is still in initial stages and as the scale hasn't been reached till now, it will require time for the access devices to be cost effective to price sensitive customers in India.

- **Enterprise**: Enterprise require high bandwidths for more productivity and they can easily afford the same at higher ARPUs and hence will be one of the early adopters to better speeds provided by 4G technologies

- **Declining ARPU**: With declining ARPU, operators will have added incentive to look for and push 4G technologies and stop falling ARPUs and hence their margins.

- **Better Business Case**: Considering the higher cost of rolling out wireline broadband in the existing conditions in country it is better business sense to go wireless.

- **Low Broadband Penetration**: There is huge potential in the under-penetrated market such as India where broadband penetration is less than 1%.

2.4 4G/ BWA spectrum auction

2.4.1 Auction guidelines

Considering the necessity of broadband penetration and the expected benefits of the same to the economy, Government recently auctioned spectrum to be used to provide mobile services and broadband using 3G as well as broadband using 4G. DoT in consultation with TRAI conducted auction and they used auction process similar to the ones used in other countries such as UK, Germany to auction off 2 bands of 20MHz in each of the 22 circles. The auction was conducted in 2010-11 and the process adopted during the 4G spectrum auction and the associated details are given below:

Auction Rules	• Only one entity to be allowed to bid from the same Group Entity: A group entity is defined as existing licensees with common parents having at least 26% stake in these companies
Auction Timelines	• Invitation Stage (Applications): 19th March, 2010 • Final draft for application: 23rd March, 2010 • Pre-qualification of bidders: 30th March, 2010 • Auction stage: 9th March for 3G (For BWA it will start 2 days after 3G auction closes) • Payment stage: 10 days after close of auction • Grant Stage: 15 days after completion of auction and full payment
Application Requirements	• Processing fee of $2200 • Ernest money in terms of bank guarantee – Eligibility points for the auction would be based on amount of earnest money deposited (Pan-India earnest money for BWA is $56mn) • Nomination of authorized signatory
Auction Process	Auction is to be carried out in 2 stages, with all circle auctions to start and end at the same time • Clock stage to determine the spectrum lot winners • Assignment stage to assign specific frequency to the winners
Bid Price Increment	• Negative demand: 0% increase • Zero excess demand: 2% increase • Demand in excess by 1 or 2 bidders: 5% increase • Demand in excess by 3 or more bidders: 10% increase

Allocation of Spectrum	• Successful bidders are required to deposit 25% of the auction amount within 5 days and remaining 75% within next 10 days • On full payment, DoT will issue LoI and would allocate the spectrum within 15 days of full payment of auction amount • New spectrum winners will get 90 days from auction closure to fulfill license requirements (UAS License Application)

Source: DoT[11]/ FICCI report

Figure 14: Summary BWA spectrum auction process

Eligibility	• Any service provider who holds a UASL/ CMTS license or fulfils UASL criteria and will acquire one before commencing operations; or • Holds Internet Service Provider (ISP) license category 'A' or 'B'
Frequency Bands	• 4 Blocks of 20MHz of spectrum (TDD mode) in the 2.3 GHz and 2.5 GHz band
Entry Fee	• Reserve price for the auction is designated as: - USD 17.8 mn – Mumbai, Delhi and Category A circles - USD 8.9 mn – Kolkata and Category B circles - USD 3.3 mn – Category C circles
Rollout Obligations	• At the end of five years from date of spectrum allocation, the service provider needs to cover 90% of metro areas and 50% of rural SDCAs
M$A Guidelines	• M&A between UASL holder in the same service area is allowed only after 3 years from the date of license
Spectrum Usage Charges	• Spectrum charges for existing UASL/ CMTS players to be the same as the revised spectrum charges for 2G spectrum. BWA spectrum is not to be counted to arrive at the relevant slab of spectrum • Standalone BWA operators or ISP license holders will be charged 3% of AGR, after the first year of allocation of spectrum

Source: DoT/ FICCI Report[12]

Figure 15: BWA spectrum auction guidelines

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[11] DoT, "Auction of 3G and BWA spectrum, February 2010

[12] FICCI, "3G and BWA: The Next Frontier", January 2009

2.4.2 Auction results

BWA auction was successful and Government got overwhelming response from the industry[13]. The auction process went for 16 days and 117 rounds of bidding and ended with total revenue of Rs 12848 crore for the Government with the pan-India spectrum auction. The pan India bid amount closed at around 7.3x the base price of Rs 1750 crore for pan India spectrum. The only company to take pan-India license turns out to be Infotel Broadband Services (all 22 circles) followed by Aircel (8 circles), Tikona Digital (5 circles), Bharti (4 circles) and Qualcomm (4 circles) and Augere (Mauritius) (1 circle). Many companies like TATA and Vodafone decided to stay away from the auction and this helped in lowering the auction amount as competition remained contained within limits unless what is being said about 3G licenses. Still, the auction is expected to put intense pressure on the balance sheet of all the companies involved in the auction As the BWA revenue will take some time to show and the roll out will take time as it has to be done progressively in all the circles and will be possible only after 4-5 months of allotment of the spectrum.

Circles	Category	Reserve price (USDm)	Final bid price (USDm)	Actual multiple to final price	Final pan-India (USDm)	Winning operator Operator 1	Winning operator Operator 2
Andhra Pradesh	A	36	235	6.6x	706	Aircel	Infotel
Gujarat	A	36	136	3.8x	409	Infotel	Tikona
Karnataka	A	36	343	9.6x	1029	Infotel	Bharti
Maharashtra	A	36	203	5.7x	610	Bharti	Infotel
Tamil Nadu	A	36	460	12.9x	1380	Infotel	Aircel
Haryana	B	13	27	2.0x	80	Infotel	Qualcomm
Kerala	B	13	57	4.3x	172	Infotel	Qualcomm
Madhya Pradesh	B	13	28	2.1x	83	Augere	Infotel
Punjab	B	13	74	5.5x	222	Bharti	Infotel
Rajasthan	B	13	22	1.6x	65	Tikona	Infotel
U.P. (East)	B	13	32	2.4x	95	Tikona	Infotel
U.P. (West)	B	13	41	3.1x	123	Tikona	Infotel
West Bengal	B	13	16	1.2x	47	Infotel	Aircel
Assam	C	3	7	2.2x	22	Aircel	Infotel
Bihar	C	3	22	6.6x	66	Infotel	Aircel
Himachal Pradesh	C	3	5	1.4x	14	Tikona	Infotel
J&K	C	3	5	1.4x	14	Aircel	Infotel
North East	C	3	5	1.4x	14	Infotel	Aircel
Orissa	C	3	14	4.2x	42	Aircel	Infotel
Delhi	Metro	36	498	14.0x	1494	Infotel	Qualcomm
Kolkata	Metro	13	116	8.7x	349	Infotel	Bharti
Mumbai	Metro	36	510	14.3x	1529	Infotel	Qualcomm
Total		389	2,855	7.3x	8,565		

Source: DoT/ HSBC[14]

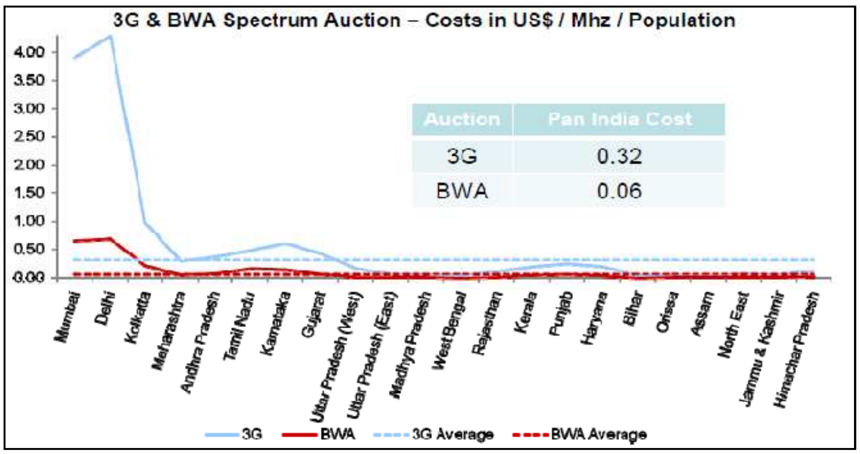
Figure 16: BWA Spectrum Winners

[13] ICICI direct research report, "BWA spectrum auction", June 2010

[14] HSBC Global Research, "Indian Telecoms", June 2010

2.4.3 Auction price comparison with 3G

Although the pan-India multiple in 4G is 7.3x it is still cheaper when compared to the 3G auction that took place before 4G auction and saw intense competition from all the major players in Indian telecom industry. Pan India cost in terms of US$/ MHz/Population for BWA comes around one-fifth of the 3G thus significantly improving chances of better returns from the 4G services to be launched within one year timeframe along with 3G and will be competing with 3G in broadband area.



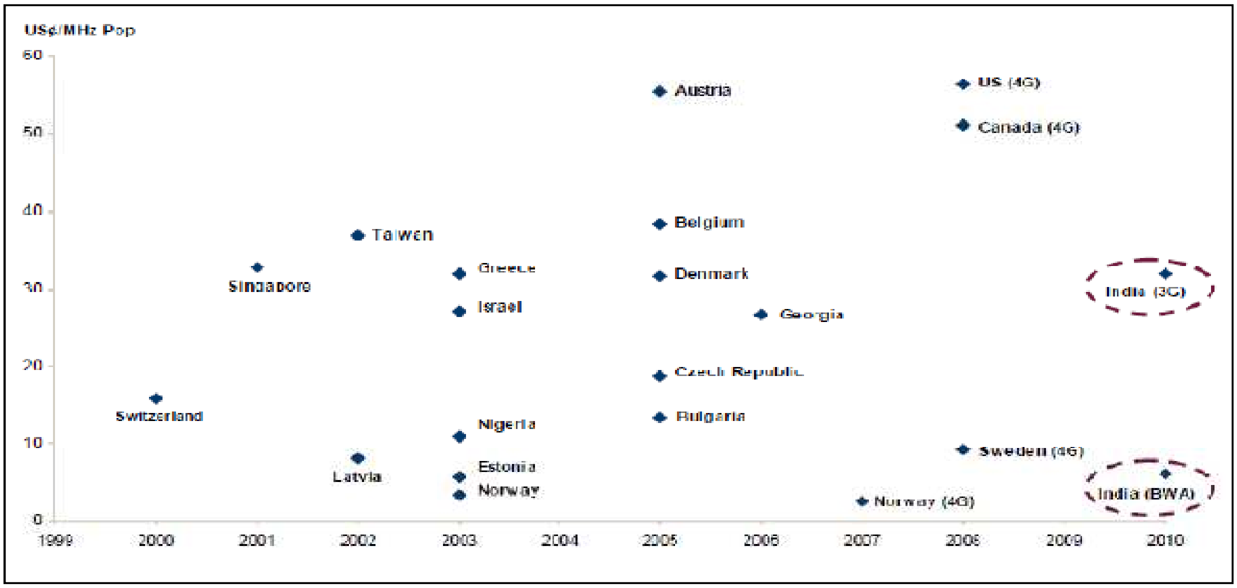
Source: Reliance Report[15]

Figure 17: 3G and BWA Spectrum Auction

2.4.4 Auction price comparison - International

Internationally auction method is being used since 2000 when Switzerland auctioned its 3G license. Since then various countries have adopted the route of the auction as it is expected to maximize the value of the spectrum and help respective Governments get the much needed revenue. When considered with global auction data, the prices paid for 3G as well as 4G are still very much competitive in India and so higher/ better IRR is expected from the license in India compared to most of other countries.

[15] Reliance Industries Limited, "BWA – Analyst report", June 2010



Source: Reliance Report[15]

Figure 18: Global trend in Spectrum auction prices

3. Historical Background

3.1 Evolution from 0G to 3G

3.1.1 0G

0G is the era of Mobile radio telephone systems which preceded the modern cellular mobile telephony technology we see nowadays. These systems are sometimes called pre-cellular and included technologies such as Push to Talk (PTT or manual), Mobile Telephone System (MTS), Improved Mobile Telephone Service (IMTS), and Advanced Mobile Telephone System (AMTS) systems.[16] These mobile telephones were available as mountable on cars or trucks as well as briefcase models. The full unit consisted of a transceiver (transmitter-receiver) mounted in the vehicle trunk and attached to the "head" (dial, display, and handset) mounted near the driver seat.

3.1.2 1G

1G refers to the start of the wireless telephony technology, which is mobile technology as we know today[17]. They constitute the analog telecommunications standards that were introduced in the 1980s and replaced by 2G digital communications. The main differentiating factor between 1G and 2G is that the radio signals that 1G networks use are analog, while 2G networks are digital. Although both systems use digital signaling to connect the radio towers (which listen to the handsets) to the rest of the telephone system, the voice itself during a call is encoded to digital signals in 2G whereas 1G is only modulated to higher frequency, typically 150 MHz and up.

3.1.3 2G

Three primary things that separated second generation 2G cellular telecom networks from previous technologies were[18]: Digitally encrypted phone conversations, Efficient systems that allowed greater mobile phone penetration levels and introduction of data services for mobile, starting with SMS text messages. 2G technologies can be divided into TDMA-based and

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[16] http://en.wikipedia.org/wiki/0G, accessed on 10/3/2011

[17] http://en.wikipedia.org/wiki/1G, accessed on 10/3/2011

[18] http://en.wikipedia.org/wiki/2G, accessed on 10/3/2011

CDMA-based standards depending on the type of multiplexing used. TDMA based GSM and CDMA based cdmaOne is being used in India. Digital signals helped in increasing efficiency in two ways:

1) Digital voice data could be easily compressed and multiplexed and thus allowed more calls to be packed into same amount of radio bandwidth.
2) Less radio power emission from digital systems ensured that cells could be smaller and thus more could be packed in same space accompanied by less expensive equipments

2G technology provided many advantages such as Digitization which ensured that digital data services such as SMS could be started, reduced fraud as cloning of sets was not possible and enhanced privacy. Health concerns were lowered due to relatively low energy level signals used in emission. But the technology has its limitations such as:

1) Weaker digital signals in a less populated signal might not reach cell tower due to relatively low frequency at which 2G works
2) Digital signals although good overall but their performance worsens when conditions gets worse and experience drop outs.

Overall 2G networks are suitable for voice services and slow data transmission and thus the technology evolved and we had GPRS (2.5G) and EDGE (2.75G):

- GPRS: General Packet Radio Service, GPRS can provide data rates from 56 kbit/s up to 115 kbit/s. It can be used for services like Wireless Application Protocol access (WAP), Multimedia Messaging Data Service (MMS) as well as for the Internet for using basic services such as email and access World Wide Web. One big difference is that in GPRS, charges are decided on the basis of megabytes used instead of per minute conversation as in 2G.

- EDGE: EDGE provides potential to increase capacity of GSM/ GPRS networks by 3 times. The specification can achieve data-rates up to 236.8 kbit/s.

3.1.4 3G

3G standards comprises of the standards set for mobile phones and mobile telecommunications services fulfilling specifications by the International Telecommunication Union (ITU) and are known as International Mobile Telecommunications – 2000 (IMT-2000)[19]. The standards include application services such as wide-area wireless voice telephone, mobile internet access, video calls and mobile TV, all in a mobile environment. The difference between 3G and the previous standards is that atleast 200 Kbits/s speed must be provided in 3G as per IMT-2000 specifications. The latest 3G standards namely 3.5G and 3.75G can be used to provide mobile broadband access of several Mbit/s to laptop computers and smart phones. Two main technologies under 3G are:

- UMTS: Universal Mobile Telecommunications System, started in 2001 and standardized by 3GPP is used in today's cell phones as hybrid between UMTS and GSM. Unlike 2G technologies such as EDGE and CDMA2000, UMTS requires setting up of new base transmission stations (BTS) and new frequency allocations. But in spite of this, it is still closely related to GSM/ EDGE as it builds upon concepts from GSM technology. Also, most UMTS handsets support GSM, allowing seamless dual-mode operation. Therefore, UMTS is sometimes marketed as 3GSM, emphasizing the close relationship with GSM and differentiating it from competing technologies. Several radio interfaces are offered, sharing the same infrastructure such as:
  - W-CDMA: Wideband Code Division Multiple Access**,** the original and most widespread radio interface. It utilizes the DS-CDMA channel access method and the FDD duplexing method to achieve higher speeds and support more users compared to most time division multiple access (TDMA) schemes used today.

  - HSPA+: Evolved High-Speed Packet Access is the latest UMTS technology variant, it can provide peak data rates up to 56 Mbit/s in the downlink in theory (28 Mbit/s in existing services) and 22 Mbit/s in the uplink.

[19] http://en.wikipedia.org/wiki/3G, accessed on 11/3/2011

- CDMA2000 system: Started in 2002 and standardized by 3GPP2.Its most used variant is the latest release EVDO that offers downstream peak rates of 14.7 Mbit/s:
    - EVDO: Evolution-Data Optimized or Evolution-Data is a telecommunications standard for the wireless transmission of data using radio signals, and is used typically for broadband Internet access. It uses multiplexing techniques including code division multiple access (CDMA) as well as time division multiple access (TDMA) to maximize both individual users' throughput and the overall system throughput. It is also standardized by 3GPP2 as part of the CDMA2000 family of standards and has been adopted by many mobile phone service providers around the world – particularly those previously employing CDMA networks. In India it is being provided by Reliance and TATA.

Although Mobile WiMAX standards formally also fulfill the IMT-2000 requirements and are approved as 3G standards by ITU, these are typically not branded 3G, and are based on completely different technologies.

The bandwidth and location information can be leveraged using 3G devices and some of the applications are:

- **Mobile TV** – a provider redirects a TV channel directly to the subscriber's phone where it can be watched.
- **Video on demand** – a provider sends a movie to the subscriber's phone.
- **Video conferencing** – subscribers can see as well as talk to each other.
- **Tele-medicine** – a medical provider monitors or provides advice to the potentially isolated subscriber.
- **Location-based services** – a provider sends localized weather or traffic conditions to the phone, or the phone allows the subscriber to find nearby businesses or friends.

Further Evolution[19]

Both 3GPP and 3GPP2 are currently working on extensions to 3G standard that are based on an all-IP network infrastructure and using advanced wireless technologies such as MIMO, these specifications already display features characteristic for IMT-Advanced (4G), the successor of 3G. However, falling short of the bandwidth requirements for 4G (which is 1 Gbit/s for stationary and 100 Mbit/s for mobile operation), these standards are classified as 3.9G or Pre-4G. 3GPP plans to meet the 4G goals with LTE Advanced, whereas Qualcomm has halted development of UMB in favour of the LTE family.

ITU IMT-2000	**Common name(s)**	**Data Bandwidth**	**Pre-4G**	**Duplex**	**Channel**	**Description**	**Areas**
TDMA Single-Carrier (IMT-SC)	EDGE	EDGE Evolution	none	FDD	TDMA	Evolutionary upgrade to GSM/GPRS	Worldwide except Japan and South Korea
CDMA Multi-Carrier (IMT-MC)	CDMA2000	EVDO	UMB		CDMA	Evolutionary upgrade to cdmaOne	Americas, Asia
CDMA Direct Spread (IMT-DS)	UMTS: W-CDMA, TD-CDMA, TD-SCDMA	HSPA	LTE			Family of revolutionary standards	worldwide
CDMA TDD (IMT-TC)				TDD			Europe China
FDMA/ TDMA (IMT-FT)	DECT	none			FDMA/ TDMA	Short-range, standard for cordless phones	Europe USA
IP-OFDMA		WiMAX (IEEE 802.16)			OFDMA		worldwide

Source: ITU [20]/ WIkipedia

Figure 19: Overview of 3G/IMT-2000 standards

[20] http://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG02.18-1-2006-PDF-E.pdf, accessed on 11/3/2011

3.2 4G

4G is the fourth and latest generation of telecommunications cellular wireless standards[21]. It is first end-to-end total IP based network and the speed requirements for 4G service set the peak download speed at 100 Mbit/s for high mobility communication (such as from trains and cars) and 1 Gbit/s for low mobility communication (such as pedestrians and stationary users).[22] With 4G systems, comprehensive and all secure IP-based mobile broadband solutions are possible for mobile devices such as laptop computer wireless modems, smart phones and other mobile devices. Further access services such as ultra-broadband Internet access, IP telephony, gaming services, and streamed multimedia can be easily provided to the users. At present technologies such as Mobile WiMAX and LTE are counted among 4G technologies.

3.2.1 WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) is a telecommunications protocol that has been designed to enable pervasive, high-speed mobile Internet access in both fixed and mobile medium. The current WiMAX revision provides up to 40 Mbit/s with the IEEE 802.16m update expected to offer up to 1 Gbit/s fixed speeds. WiMAX is also described as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". WiMAX operates on the same principles as used in Wi-Fi[23]. It involves providing around 14 wireless transmission of data using a variety of transmission modes, from point-to-point links to portable Internet access. According to reports, WiMAX provides broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations and up to 5 - 15 km for mobile stations. As the delivery mode doesn't need line of sight presence and thus this technology is also called "Non Line of Sight Transmission".

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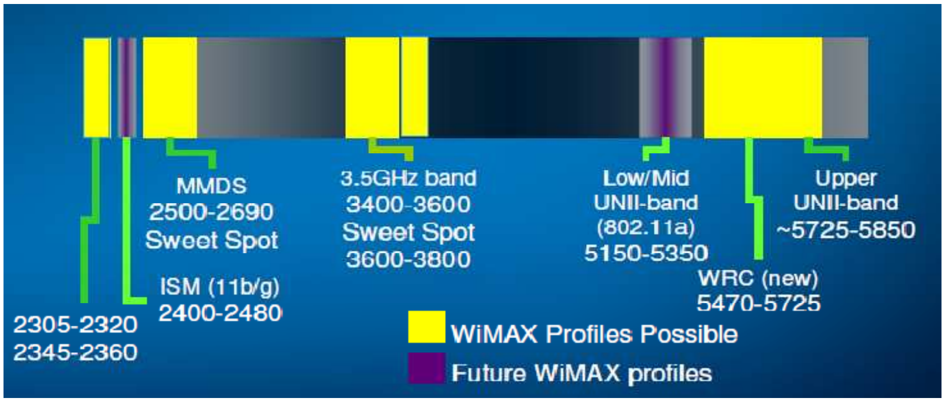
[21] http://en.wikipedia.org/wiki/4G, accessed on 11/3/2011

[22] http://www.itu.int/ITU-R/index.asp?category=information&rlink=imt-advanced&lang=en, accessed on 11/3/2011

[23] IMRB, "Mobile Internet in India", December 2009



Source: Intel report[24]

Figure 20: WiMax Profile: Radio frequency spectrum

The various types of receivers possible are fixed-wireless type, Nomadic type and Mobile type. Due to the bandwidth and range of the WiMAX products, various applications are possible such as:

- Portable mobile broadband connectivity spanning across various cities and countries through a mix of devices: Using WiMAX companies have started providing alternate to incumbent broadband providers and the increased competition will lead to further reduced ARPUs and thus will benefit customers. WiMAX is a possible replacement candidate for cellular phone technologies such as GSM and CDMA, or can be used as an overlay to increase capacity and backhauling. At present copper wire, satellites and microwave links are used for backhauling which can be easily replaced by cost effective WiMAX. One unique use of WiMAX was found during disasters such as Katrina and Tsunami when WiMAX acted as the only viable medium for the communication as other mediums couldn’t be used and thus it is expected to form a backup network in case of emergency in near future

- Better wireless alternative to cable and DSL for "last mile" broadband access especially in inaccessible and rural areas: The relatively cost of deploying a WiMAX network (in comparison to GSM, DSL or Fiber-Optic) is low and thus it is now possible to provide broadband in places where it might have been previously economically unviable

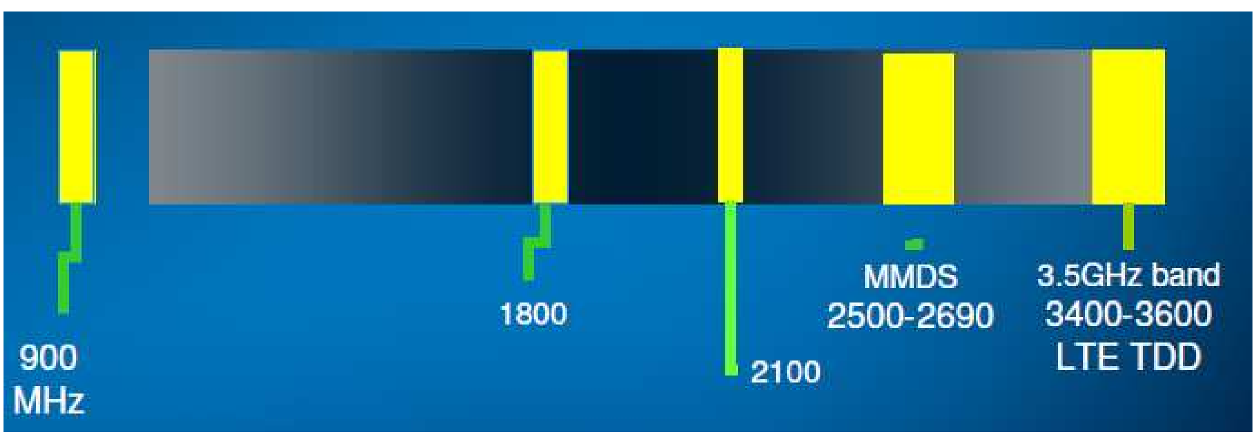
[24] Intel Corporation, “Internet everywhere – 4G technology”, April 2010

- Data and telecommunications such as Voice over Internet Protocol (VoIP) and Internet Protocol Television (IPTV services) which is also known as triple play. Availability of option to combine various services in single medium will open path for partnerships between various wireless and cable companies and benefit all partners involved.

- As a source of Internet connectivity as part of a business continuity plan

3.2.2 LTE

Long Term Evolution (LTE) is the latest standard in the mobile communications technology branch that produced the GSM/ EDGE and UMTS/HSPA network technologies[25]. The LTE specification provides downlink peak rates of at least 100 Mbps, an uplink of at least 50 Mbps and round-trip times of less than 10 ms. LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time division duplexing (TDD). LTE is also an IP based network architecture designed to replace the GPRS Core network and ensure support for and the mobility between different networks for example GPRS and WiMAX. The main advantages with LTE are high throughput, low latency, plug and play, combination of FDD and TDD in the same platform, an improved end-user experience and a simple architecture resulting in low operating costs. LTE will also support seamless passing to cell towers with older network technology such as GSM, cdmaOne, UMTS, and CDMA2000.



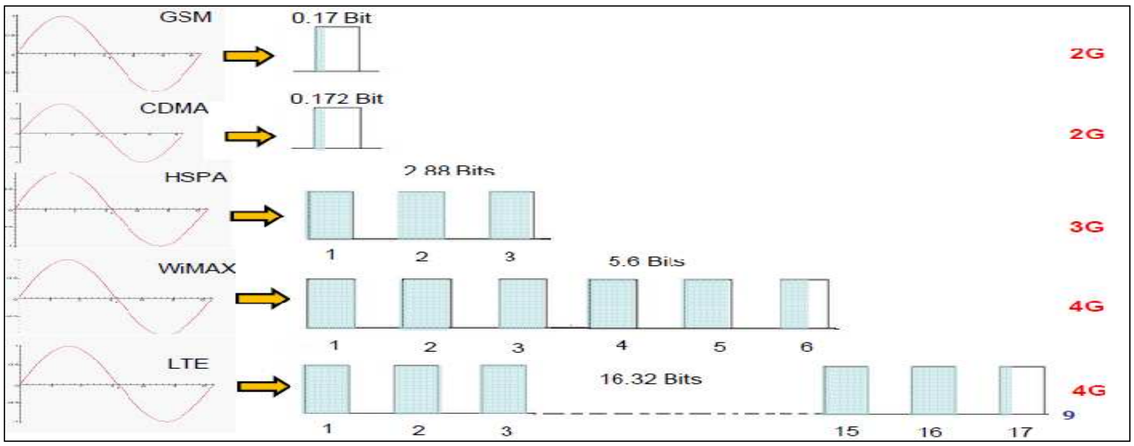
Source: Intel report[24]

Figure 21: LTE profile: Radio frequency spectrum

[25] http://en.wikipedia.org/wiki/3GPP_Long_Term_Evolution, accessed on 11/3/2011

3.2.3 4G versus rest technologies

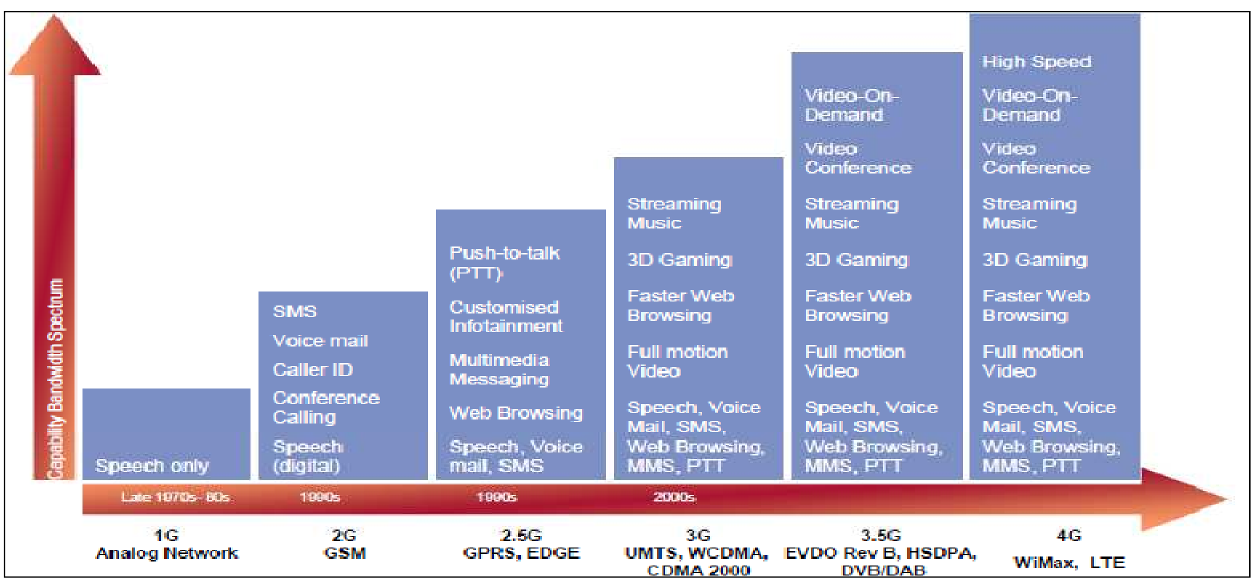
4G technologies are at the frontend of the evolution process that started with 0G and still continuing. With the evolution technologies have become more mobile and flexible allowing for the newer applications such as better backhauling, triple play and faster broadband. One of the important contributing factors has been the increasing bits that can be packed per Hertz and thus deriving more data in the limited spectrum available as can be seen below:



Source: Reliance report[15]

Figure 22: Mobile technology- Bits per Hertz

Increasing speed is in turn allowing users to move towards more complex and data intensive applications and unbundling the power of the hardware and software technology.



Source: Reliance Report[15]

Figure 23: Mobile technology evolution

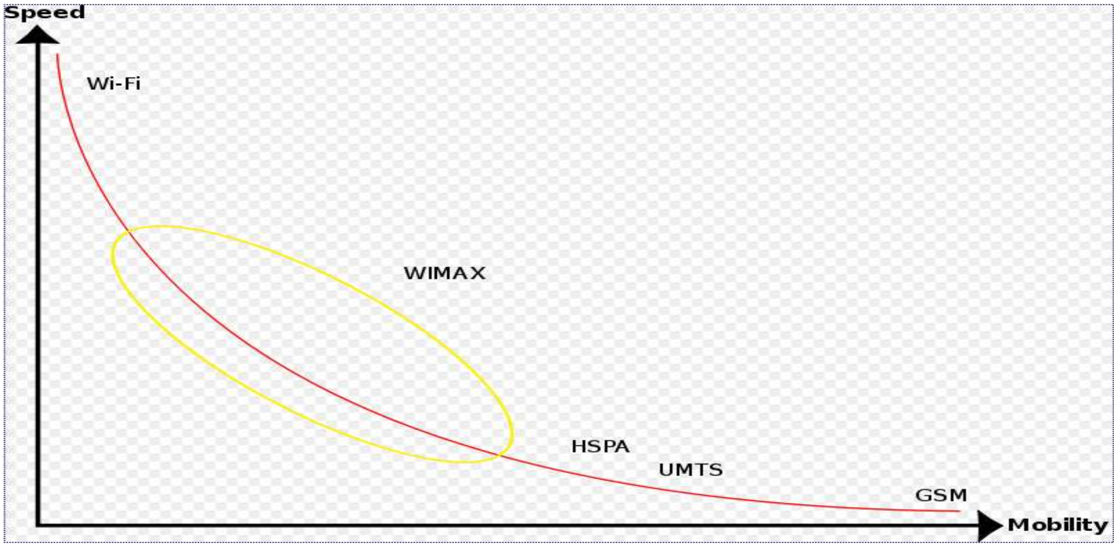
A more comprehensive comparison is shown below:

Standard	Family	Primary Use	Download (Mbits/s)	Uplink (Mbits/s)
WiMAX - advance	802.16m	Mobile Internet	1296 (in 20MHz bandwidth)	100 (in 20MHz bandwidth)
LTE - advance	UMTS/4GSM	General 4G	1296 (in 20MHz bandwidth)	100 (in 20 MHz bandwidth)
WiMAX	802.16	Mobile Internet	128 (in 20MHz bandwidth)	56 (in 20MHz bandwidth)
LTE	UMTS/4GSM	General 4G	100 (in 20MHz bandwidth)	50 (in 20 MHz bandwidth)
Wi-Fi	802.11	Mobile Internet	300 (in 4x4 configuration in 20MHz bandwidth) or 600 (in 4x4 configuration in 40MHz bandwidth)	
EDGE	GSM	Mobile Internet	1.6	0.5
UMTS W-CDMA HSDPA+ HSPA+	UMTS/3GSM	General 3G	0.384 14.4 56	0.384 5.76 22
UMTS-TDD	UMTS/3GSM	Mobile Internet	16	
EVDO 1x Rev. 0 EVDO 1x Rev. A EVDO Rev. B	CDMA2000	Mobile Internet	2.45 3.1 4.9xN	0.15 1.8 1.8xN

Source: Wikipedia

Figure 24: Comparison of Mobile Internet Access methods

WiMAX provides lot of flexibility in terms of the speed provided when compared along with the mobility provided. In all the digital technologies, with the mobility the speed decreases as bit error rate starts increasing but WiMAX still provides better output when compared to most of the available technologies.



Source: Wikipedia, Copyright Benjamin M. A'Lee

Figure 25: Speed versus Mobility of wireless technologies

3.2.4 Comparison with Wi-Fi

Both technologies are sometimes confused due to the similarity in the function and as both are used to give wireless broadband connections but both have distinctive properties that differentiate them and give them their own unique usage as shown below:

	WiMAX	**Wi-Fi**
Range	Long range system, covering many kms	provides access to a local network
License	Uses licensed or unlicensed spectrum	Unlicensed spectrum only
Users	More popular with the business user	More popular in end user devices
Type of Media Access Control	Connection-oriented	connectionless and contention based
QoS	Based on connections between the base station and the user device. Each connection is based on specific scheduling algorithms	Contention access based - all subscriber stations that wish to pass data through a wireless access point (AP) are competing for the AP's attention on a random

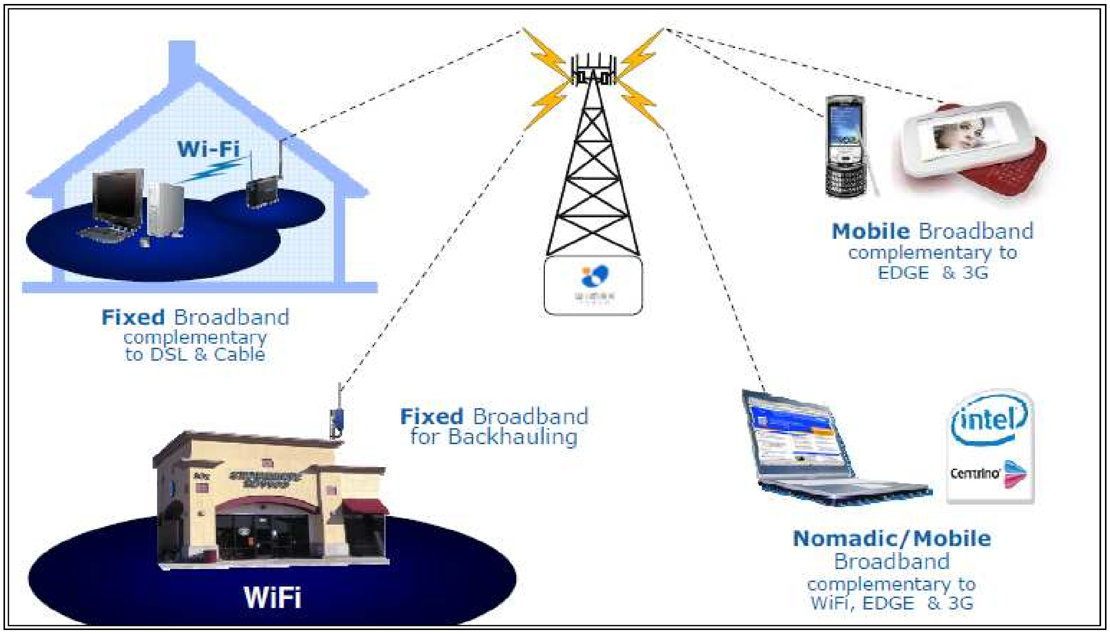
		interrupt basis.
Networks	Peer-to-Peer (P2P) and ad hoc networks, but end user devices must be in range of the base station.	Peer-to-Peer (P2P) and ad hoc networks, and direct ad hoc or peer to peer networking between end user devices without an access point is also allowed
Even though both technologies are adept for different scenarios they are still used together by some providers. WiMAX network operators typically provide a WiMAX Subscriber Unit which connects to the metropolitan WiMAX network and provides Wi-Fi within the home or business for local devices (e.g., Laptops, Wi-Fi Handsets, smart phones) for connectivity. This enables the user to place the WiMAX Subscriber Unit in the best reception area (such as a window), and still be able to use the WiMAX network from any place within their residence		

Source: Wikipedia

Figure 26: WiMAX and Wi-Fi comparison

3.3 Typical 4G network

A typical 4G broadband network consists of a tower which is also called BTS, which is Base Transmission Station which houses all the required equipments for the transmission of the frequencies to make WiMAX available. There can be different types of the end users such as Fixed Broadband users where WiMAX usually complements DSL and cable broadband, Mobile laptop broadband users where WiMAX competes with WiFi/ EDGE & 3G, Mobile cellphone broadband users where the usual competitors are EDGE and 3G and the last but rising use is in backhauling to connect to other networks.



Source: Intel report[24]

Figure 27: Typical 4G network

3.4 4G success deployment worldwide

Since 2008, 4G networks have come to existence in various parts of the world with various degrees of successes and issues.

Company	Country	Comments
kt	Korea	▪ First company in Korea to explore wireless broadband services ▪ Deployed approximately 600 base stations covering 12 million people ▪ Established itself as the wireless broadband leader in Korea
clearwire wireless broadband	USA	▪ Operates in the United States, Ireland, Belgium, Spain, Denmark (with Danske Telecom) and Mexico (with MVSNet) ▪ Offers internet speeds of up to 6 Mbps per user device ▪ Launched 4G WIMaAX in Jan 2009
Yota	Russia	▪ First mobile WIMAX network in Russia, launched in September 2008 ▪ Offers internet speeds of up to 10 Mbps per user device ▪ Installed 150 base stations in Moscow and 80 base stations in St. Petersburg with peak data rates of about 180 Gbit per second
UQ Communications	Japan	▪ Only telecom company in Japan providing nationwide mobile services based on WIMAX ▪ Aims to extend coverage to 90% by 2012
P1	Malaysia	▪ First operator to launch commercial WiMAX operations in Malaysia in 2008; acquired 100k subs within 6 months of launch ▪ Investment plans of over $300mn in the next 5 years

Source: Protiviti Research[45]/ Reliance report[15]

Figure 28: BWA success case studies

4G is being advertised as unique and history making event with major stress on the speed and flexibility provided by the same.

Source: Intel report[24]

Figure 29: 4G advertised

3.5 Future Trends

According to the IMRB Research[23] the future trends which are expected to be observed for Mobile internet in India due to advancements in the devices, technologies and the content delivery are as following:

- **Ubiquitous Connectivity:** The rise in the demand for the connectivity from the enterprises and consumers will lead to the connectivity among the various platforms. Ubiquitous connectivity designates a seamlessly integrated platform for interactions and collaboration across diverse and global communication environments. This will enable users to access and share the content over various platforms with complete mobility.

- **Fixed Mobile Convergence (FMC):** Fixed mobile convergence provides way to integrate the wire line and wireless technologies and services to create a single telecommunications network. FMC promises to overcome the physical barriers that prevent the telecom service providers from targeting the potential customers with all types of services. This initiative will offer the opportunities to the wire line service providers to not remain tethered to the landline networks and wireless operators will be able to utilize the resources to satisfy the growing demand of mobile subscribers. This initiative will lead to seamlessly connectivity for all devices, access points, applications and underlying networks, to deliver an enhanced user experience.

- **Quadruple Play:** The transformation of telecommunication technologies will enable the triple play service of voice, data, and video with the wireless service i.e. mobility. The implementation of this quadruple play services has restricted to the some of the countries of the world. With the improvement in the technologies, it has been expected that users will be able to access these uninterrupted services even on the move.

- **Mobile Advertising:** Mobile as a device offer lot of opportunities for the low PC but high mobile phone penetrated Indian market. Considering the success of mobile advertising in some of the countries globally, relevant formats of the mobile advertising will be introduced in the Indian market.

- **Unified Messaging Service (UMS):** Traditional communications systems delivered messages into several different types of stores as per the type of message. Unified Messaging Service will help in bringing together all messaging media such as voice messaging, SMS, email into a single interface which is accessible from variety of devices. Based on the functionalities offered by this system, this service it will be more helpful for the enterprises compared to the users.

4. Literature Review

With time, telecom industry has been overseeing various changes and the industry is becoming more and more dynamic. Ever evolving technology which is gaining pace day by day, worldwide auctions and intense competition has ensured that it is not only difficult but impossible to evaluate future potential of investments in the sector using traditional methods such as Discounted Cash Flow (DCF). With various options available now with the telecom company a more and suitable method is using option method for valuation. In a paper, Alleman (2002)[26] describes real option and associated benefits in using the approach for telecommunication projects. He mentions that in traditional DCF method the valuation is static in nature as it doesn't take into consideration the managerial flexibility such as option to delay, option to expand or option to abandon, option to contract etc. Traditional capital budgeting fails to account for this flexibility and fails to integrate with strategic planning. According to the author, real options are relevant to telecommunications in several areas such as: Strategic evaluation, estimation and cost modeling. The major planning in strategy area has been limited to the budget estimation and scenario analysis based on mainly DCF. This was era of regulatory strategy but with changing times price elasticity, uncertainty and other economic considerations have taken centre stage and thus real option approach is the need of hour. According to author, many behavioral assumptions that are taken as embedded in econometric structures and are necessary for estimations have been invalidated by real option approach and should be adopted. Traditionally forward looking costs methods used around the world have been base on cost models whose foundation are traditionally applied to DCF but can be easily adapted to real option models. But author cautions against adding the real option result linearly to the DCF result.

Taking the argument forward and expanding it further is the paper by Mastroeni and Naldi (2009)[27]. Authors took into consideration, side obligations and commitments that come bundled with licensee and the restriction on the transfer of the license. This gives rise to the

[26] Alleman, James, "A new view of telecommunications economics", Telecommunications Policy, Vol. 26, pp. 87-92, 2002

[27] Mastroeni, Loretta, Maurizio Naldi, "A real option model for the transferability value of telecommunications licenses", Annals of Telecommunications, Vol. 65, No. 3-4, pp. 201-210, 2009

transferability option value and add to the existing option value. Authors applied various settings related to the reselling price, expiry time of the option and the variability of the telecommunications market and found that reselling price and the volatility plays the most crucial role and the option's value increases superlinearly with an increase either in the reselling price or in the volatility. Also option value was found to grow no more than linearly with the expiry time and the growth rate gets lower as the reselling price increased. Authors also found out that to assess the value of the option when the side conditions are known (or at least estimated), the method to negotiate the side conditions should also be used. The two parameters that are in control, that are reselling price and the expiry time should form the part of the license itself or the contact and the third parameter, that is volatility may be left out as it is not in the control. These parameters can then be tuned to reconcile the price of the option with its exercise conditions.

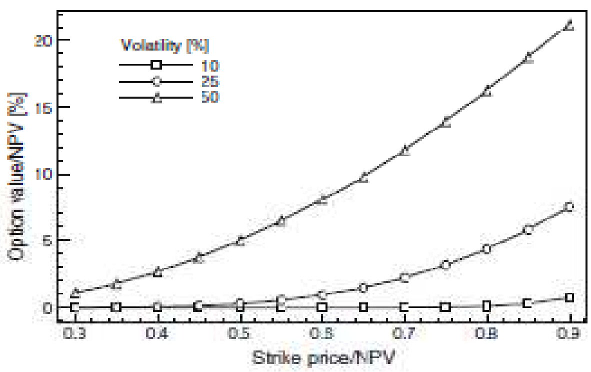


Figure 30: Impact of the expiry time on the

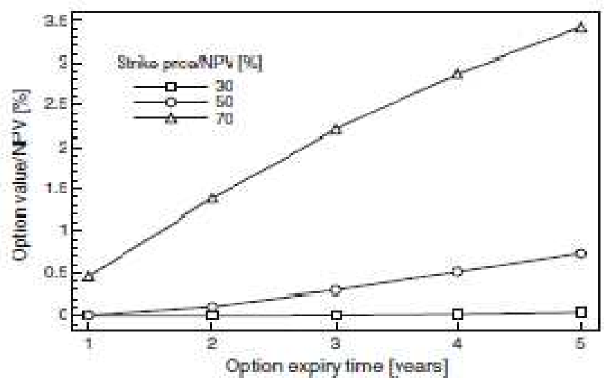


Figure 31: Impact of the license reselling price

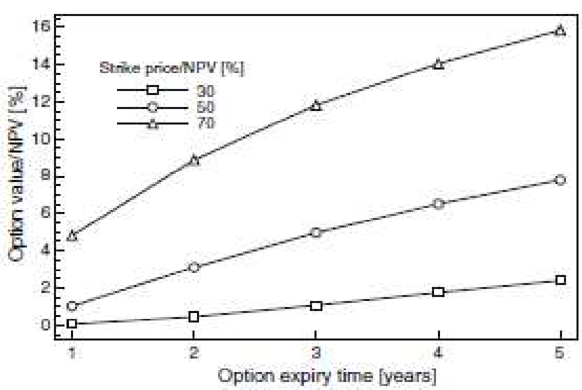


Figure 32: Impact of the expiry time on the reselling option's value

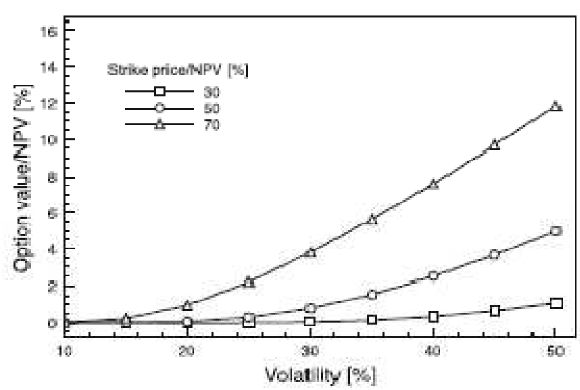


Figure 33: Impact of the volatility on the reselling option's value

There have been many studies of previous auctions mainly of 3G auction wherein real option approach has been used along with traditional DCF valuation approach. In an article Basili and Fontini (2003)[28] tried to evaluate if too much was paid for the 3G license. They calculated aggregate option value of the UK 3G telecom licenses using the expected revenues from the 3G business, capital expenditure to be incurred in setting up of the infrastructure and the operating costs in maintaining the operations for the period of the license. They found the aggregate revenue extracted by the UK Government to be slightly less than the aggregate price of the license paid by the telecom companies who won the licenses. The justification for selecting UK 3G auction for analysis was given that UK auction has been found to be most efficient in the article by Binmore and Klemperer (2002)[29]. But after two years of the auctions, doubts were casted on the efficiency of auction as the telecom companies saw fall in share prices and unsustainable burden of debt which nearly undermined the other business lines of these companies. The article showed that the value paid by telecom operators is slightly less than the expected total value from the license and thus in the long run any lowering in the performance of the operators should not be due to the high license fees paid but due to incapability of the operators to give “killer applications” to the users in order to attract them, technical difficulties in providing full capability networks at all places combined with world-wide economic downturn resulting in less than forecasted customer base. The article ends with a positive note that is full time horizon equal to the license duration is taken into consideration than the licenses will yield good returns for all telecoms.

In another paper by Stille et all (2010)[30], authors analyzed the contribution of the real option method to the decision making process in the telecommunications industry and selected 3G auction prices in Brazil. Considering only traditional method of discounted cash flow showed

[28] Basili, Marcello, Fontini, Fulvio, "The option value of the UK 3G Telecom licenses: Was too much paid?", info, Vol. 5 Iss: 3, pp.48 – 52, 2003

[29] Binmore, K. and Klemperer, P., “The biggest auction ever: the sale of the British 3G telecom licenses”, Economic Journal, 2002

[30] Stille, R., Lemme, C., Brand , L, “An application of Options of the Royal Evaluation of the License of the benefits system 3G Mobile Telephony Services in Brazil”, Journal of Finance, Rio de Janeiro, Vol 8, No. 3, 329-349, 2010

telecoms to be at loss but when coupled with the value due to the option embedded with the license, they found 64% better value and thus making the license profitable in the long run. The value in using real option approach lies in the presence of the high degree of uncertainty in implementation of a project such as 3G, managerial flexibility as well as high degree of exclusivity or barrier to entry. The high degree of uncertainty exists due to various reasons such as uncertain/ untested new technology, uncertainty about services and volume of subscribers/ users, uncertainty about taste and preferences of customers in future as well as socio-economic factors present in the market such as income levels, education levels and the age, all of which are out of control of the company. Managerial flexibility is derived from the option to buy the license or delay it or simply not take license, option to invest in the network for new technology and the option to select the cities or services that manager will like to give. Manager can decide the parameters of the network in terms of the scale and capability according to its expectations about the market. There can be rules and regulations in place that might limit this flexibility to some extent. But flexibility in terms of network capacity such as density in selected areas, choice of technology etc is still in hands of the managers. The third and last value addition to the option comes from the exclusivity in terms of holder of the exclusive spectrum which creates barrier to entry and thus restricts competition.

In another paper, Moja and Mkhize (2009)[31] examine applicability of real option valuation techniques by cellular telecommunication operators in South Africa when making capital investment decisions in next-generation service orientated architectures. They used both Black-Scholes and Binomial models to examine their effectiveness in valuing capital investments within a cellular telecommunication industry in South Africa. Results show that real option valuation techniques are effective in analysing investments in cellular telecommunication industry. Their strengths are mostly demonstrated when determining the value of strategic options that are added to traditional (base-case) net present value.

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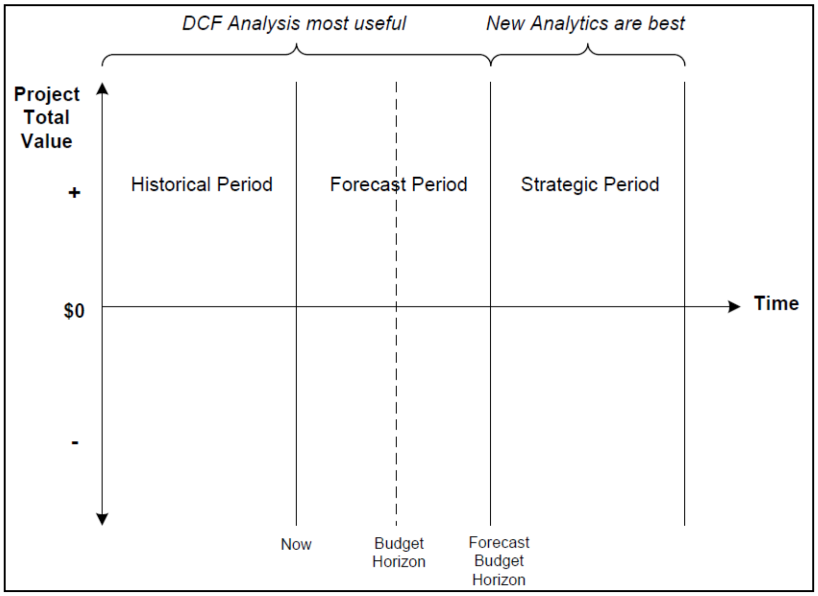
[31] Moja, N., Mkhize, M., "The application of real option valuation techniques in the cellular telecommunication industry in South Africa", South Africa Journal of Business Management, Vol. 40, No. 3, 2009

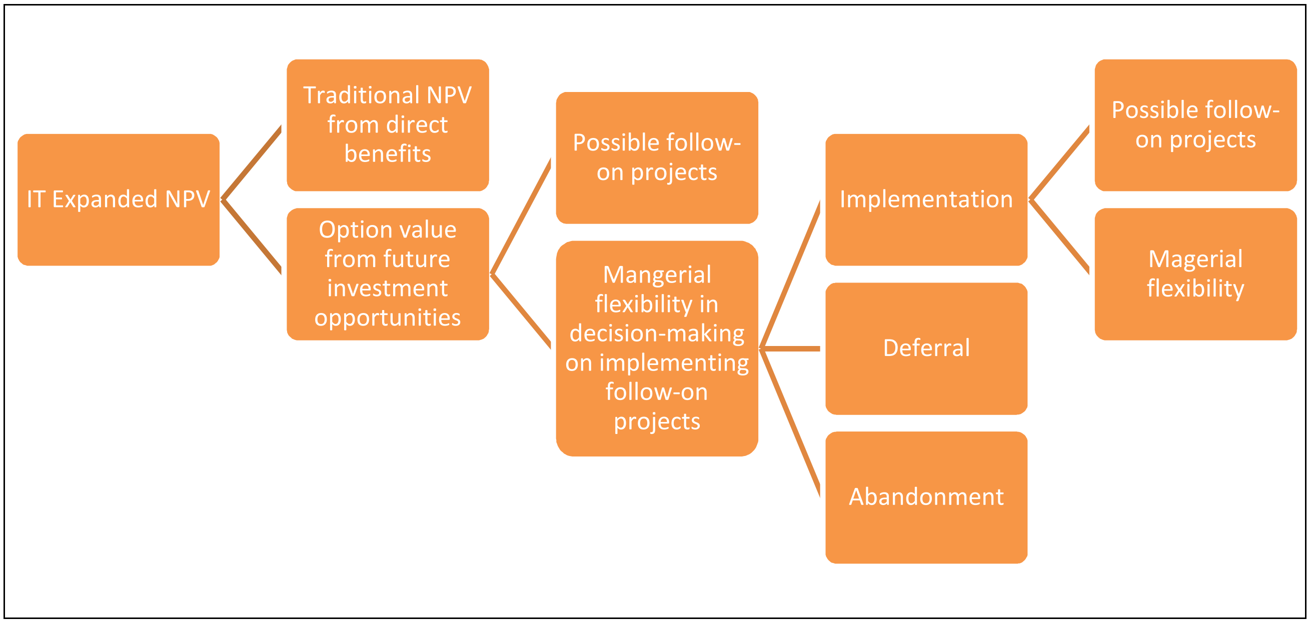


Source: Mun, 2006[32]

Figure 34: Traditional versus new analytics

Authors further suggest using the expanded NPV (extended DCF) method for valuing the option-inclusive value of the project. The expanded NPV method is defined as the sum of the traditional NPV and the expected value of future projects made possible by the initial investment. In other words, the expanded NPV for IT projects comprises the sum of traditional NPV (obtained through DCF) and the value of embedded options provided by the initial infrastructure or technology investment. The embedded options provide management with strategic flexibility for future project expansion, deferral or abandonment. Follow-on projects in the form of compound options (options-on-options) are also possible. The similar analysis is possible for real option approach to the telecommunications industry especially for the spectrum licenses as it provides various flexibilities when it comes to the implementation part and the time and method of use of the spectrum license.

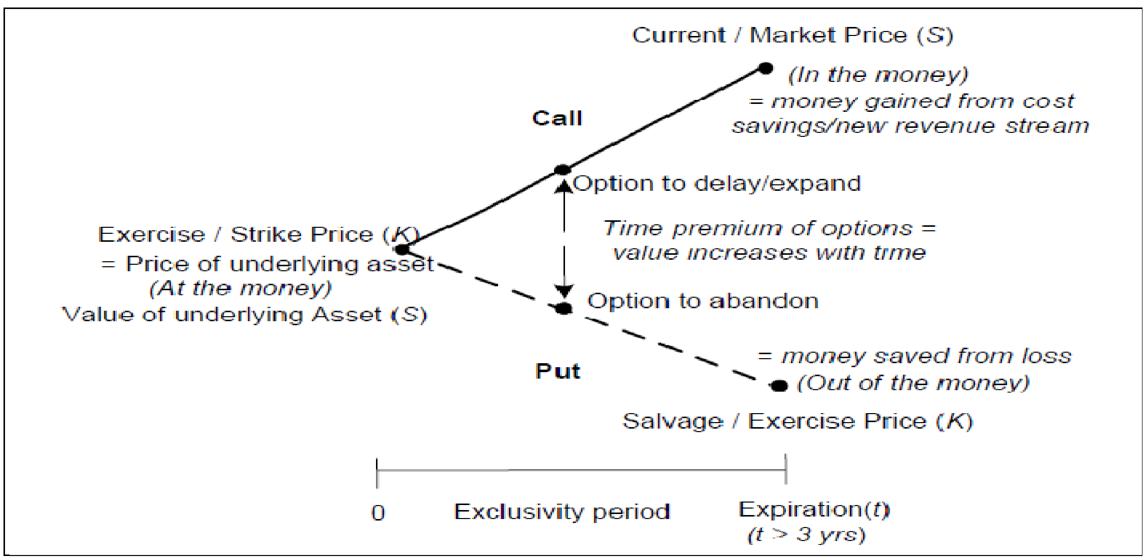
[32] Mun, J. 2006. Real options analysis – tools and techniques for valuing strategic investments and decisions. 2nd Edition. New Jersey: Wiley Finance.



Source: Dai, Kauffman & March (2000)[33]

Figure 35: Option-inclusive value of an IT project

A more illustrative approach was given by authors showing various aspects of the real option:



Source: Damodaran (2001)[34]

Figure 36: Illustration of an option pricing model

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[33] Dai, Q., Kauffman, R. J. & March, S. T., 'Analyzing investments in object-oriented middleware: An options perspective.' In Proceedings of MIS Research Center Working Papers Carlson School of Management, Minneapolis, University of Minnesota, p.p.1–27., 2000

[34] Damodaran, A., "The dark side of valuation", New Jersey: Prentice Hall, 2001

Another attempt to valuate telecommunications technology, specifically UMTS was made by Herbst and Walz (2001)[35]. Authors adopted real options approach to analyze the value of auctioned UMTS-licenses at that time, focussing on Germany as the largest European market. They developed a real options model with abandonment as well as a growth option. Due to lack of concrete forecast, they suggested and used an indirect approach by assuming a stochastic process for the number of mobile phone users in Germany. They further used numerical analysis rather than on closed form solutions in valuing flexibility inherent in the UMTS investments. On the basis of a sensitivity analysis they found out that the initial customer base of a mobile phone company and the realized net cash flows per user are the two most important and crucial parameters in establishing the value of the option. Also they found that the results will be different for incumbent and new standalone player as it will be difficult for a new player to be competitive to the incumbent players and will have to ramp up the subscribers fast in order to catch up.

Real option approach has been used for areas other than telecommunications such as for valuating Intellectual Property rights such as by Chang et al (2005)[36]. Real option approach to valuate Intellectual Property rights is an acceptable methodology but as pointed out by the authors the assumption of the constant rate-of-return might not be always true and thus there is need to vary volatility with time in either direction that is increasing or decreasing with time. Authors in the paper incorporated a sensitivity variable to account for the volatility of the expected rate of return and modified it with time. Other major findings were that Vega will be negative when option is deep-in-the-money. If the rate-of-return shortfall is variable and increases with volatility, option value would have a negative relation with volatility.

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[35] Herbst, Patrick, Walz, Uwe, "Real Options Valuation of Highly Uncertain Investments: Are UMTS-Licenses Worth their Money?", Department of Economics, University of Tuebingen, 2001

[36] Chang, Jow-Ran, Hung, Mao-Wei, Tsai,Feng-Tse, "Valuation of Intellectual Property- a real option approach", Journal of Intellectual Capital, Vol.6, No.3, pp. 339-357, 2005

Application of real option in yet another field was given by Benaroch and Kauffman (1999)[37] in their paper on IT investment decisions making. Authors pointed to the lack of authoritive and concrete application of real option valuation to IT projects and provided three insights: provides a formal theoretical grounding for the validity of the Black-Scholes option pricing model in the context of the spectrum of capital budgeting methods that might be employed to assess IT investments, showed why the assumptions of both the Black-Scholes and the binomial option pricing models place constraints on the range of IT investment situations that one can evaluate that are similar to those implied by traditional capital budgeting methods such as discounted cash flow analysis and presented the first application of the Black-Scholes model that uses a real world business situation involving IT as its test bed. They implemented real option on a timing analysis of the deployment of point-of-sale (POS) debit services by the Yankee 24 shared electronic banking network of New England. They found that projects which involve infrastructure development and wait-and-see deployment opportunities should be evaluated using real option approach as it can handle timing issues, scaling or even abandonment as companies gets to know about the business environment with time only. The main issues that remains with using the real option pricing is the restrictions on using the log-normality of the perceives value of the IT project and the unavailability of the information to calculate the variance of the returns from the project. Authors classified IT projects in various types such as IT infrastructure investments (investments made without expectation of immediate payback but forms the basis of the follow on investments that will convert investment opportunities into the option's underlying asset, for e.g. intranet and multi-media user interface technologies, financial and operational risk management technologies and security safeguards, data warehousing etc), Emerging technology investments (projects with uncertain cost, adoption and diffusion, the value of the underlying asset is subject to both changing expectations of the future costs on the part of the analyst and the market at large. In this case, the impact of *stochastic cost* (uncertain exercise price) drives the use of option pricing. For e.g. Internet advertising and selling, migration to an electronic market mechanism for transacting etc. In all these case the future cost attached with the exercising an option to build on a network, a market mechanism or a standard, is unknown today), Application

[37] Michel, Benaroch, Kauffman, Robert J., "A case for using real options pricing analysis to evaluate information technology project investments", Information Systems Research, Vol. 10, No. 1, pp. 70-86, 1999

design prototyping investments (With prototyping, the firm aims to maximize the value of an application development project whose value will ultimately be determined by how well its functionality can remain in synch with the support needs of a changing business process. The value inherent in the underlying asset is of somewhat less interest to the firm than the ability to react: to both adapt and change the application's functionality as required to remain competitive. When there is considerable uncertainty in an organization about whether an application will be able to "do the job" when it is delivered, or there is risk aversion on the part of management in making capital investments in IT, efforts to stage or "chunk" such projects, and monitor their payback over time, is an appropriate approach. From this perspective, much of the value of a prototype project will be in the options that it offers the firm in the future) and last being Technology-as-product investments (When the technology is a core part of a product, issues of level of commitment and ramp up, timing and roll out, and delay and abandonment must be considered. Here the benefit is derived from framing such choices in the context of option pricing by focusing on such elements as time remaining to exercise, when the option matures and by tracking the value of the option to change the course of a project. For example, Otis Elevator and the decision to re-capture the after-market for its elevator servicing, Chemical Bank's failure with the Pronto home banking project, Morgan Bank's success with RiskMetrics for financial risk management in international commercial banking, and First Boston Corporation's decision to create products and a new company, Seer Technologies, from what had been a major systems infrastructure building project etc.). Authors have further argued that option pricing models can be applied to capital budgeting decisions involving non-traded information technology assets.

5. Methodology

This research calculates the aggregate value of the 4G spectrum licenses auctioned in India in financial year 2010-2011. In order to calculate the aggregate value, 4G spectrum license has been treated as a project. The methodology adopted is as defined below:

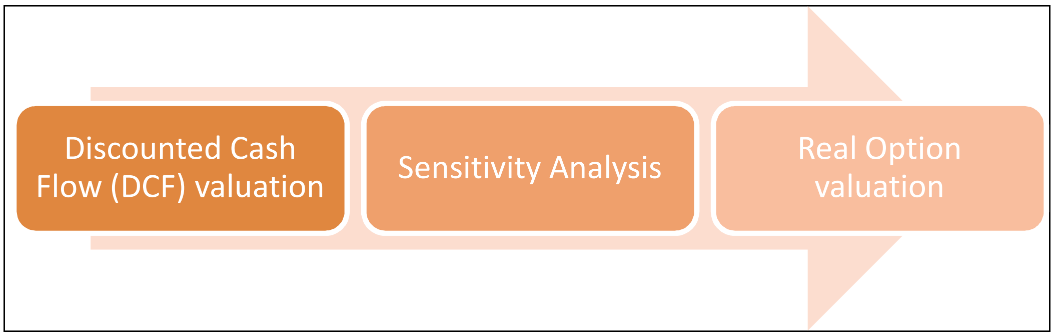

Figure 37: Steps in valuation

Step1: DCF valuation

Discounted Cash Flow method has been used to evaluate the Net Present Value (NPV) of the expected cash flows/ earnings from the deployment of the spectrum auctioned for implementation of 4G/BWA technology. The calculations and the forecasts of various parameters done in DCF will serve as base data for the next steps of valuation, which is using Real Option. The assumptions, projections and forecasts used in the DCF valuation are explained in next chapter on data.

Step2: Sensitivity Analysis

- Sensitivity analysis has been done on the NPV and IRR obtained from the DCF valuation model in order to analyze the risk associated with the project and obtain the safe range in which the project can be executed profitably.

Step3: Real Option valuation

- Real option valuation has been used to evaluate the optionality available with the Telecom operators who have won spectrum licenses. The nature of optionality has been identified and Black schools formula used to evaluate the optionality.

5.1 Discounted Cash Flow Valuation

The two standard calculations covered under DCF valuation are presented below:

- **Net Present Value Method**: Under this method present value of the company is calculated by discounting the cash flows expected from the project at a risk adjusted rate of return. NPV is the difference of the present value of cash inflows from the project and the present value of the investment overlay that will go into the project. Here Investment overlay includes capital expenditure as well as license costs.

$$NPV = \sum_{n=0}^{n=T} \frac{C_{in}}{(1+R)^n} - \sum_{n=0}^{n=T} \frac{C_{on}}{(1+R)^n}$$

Where,
C_{in} = Cash inflow in period 'n'
C_{on} = Cash outflow in period 'n'
T = Life of the project
R = Risk adjusted discount rate of the project

The above equation can be re-written as,

$$NPV = S - K$$

Where,
S = Net present value of the cash inflows from the project
K = Net present value of the investment overlay for the project

The decision criterion for selecting a project based on NPV method is,

NPV > 0: Select

NPV <= 0: Reject

- **Internal Rate of Return:** Internal rate of return is that discount rate at which NPV of the project becomes zero. That is it is the rate of return generated by the project and thus gives a clear cut-off rate. The equation for IRR is given by

$$\sum_{n=0}^{n=T} \frac{C_n}{(1+IRR)^n} = 0$$

Where,

T = Life of the project

C_n = Net Cash flow in period 'n' inclusive of investment outlays

IRR = Internal Rate of Return (Discount rate)

The decision criterion for selecting project based on IRR is,

IRR > R: Select

IRR <= R: Reject

Where,

IRR = Internal Rate of Return

R = Risk adjusted rate of return required from the project

Discounted Cash Flow method gives the static value of the project as seen in the Literature review and thus is apt for the project where there is no managerial flexibility but as we discussed earlier, in case of spectrum and subsequent deployment of the 4G technology, managers have ample flexibility such as to delay, abandon or expand and thus DCF alone is not sufficient to calculate the exact value of the spectrum and thus we will proceed to the Real Option

5.2 Real Option Valuation

For calculating the value the Black-Scholes model given by Damodaran (2000)[38] has been used which is defined as below:

$$Real\ Option\ Value = S.e^{-qt}.N(d_1) - K.e^{-r_f t}.N(d_2)$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r_f - y + \sigma^2\right)t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

[38] Damodaran, Aswath, "The option of Real option", Journal of Applied Corporate Finance, Vol. 13, No. 2, pp. 29–44, 2000

Where,

Parameter	In context of Real Option	In context of Financial Option
S	Present Value of cash flows expected from the project	Stock Price
q	Opportunity Cost of not Expanding (Explained Below)	Dividend Yield
T	Expected Competitive Advantage Period/Rights for Expansion	Time to Expiration
$\mathbf{r_f}$	Risk free rate of return on 10 year GOI bond	Risk free rate of return
K	Present Value of Capital Costs	Strike Price
$(\sigma)^2$	Volatility of Project Value	Volatility of Return on Stock

Figure 38: Real option parameters

$N(d_1)$ & $N(d_2)$ are normal cumulative distributions function which gives the range of the likelihood of the real option viability before expiration date, T.

With regard to 4G spectrum auction, there are two types of players, incumbents who are already providing broadband service either as DSL or cable or other wireless technologies or standalone players who will be starting to provide broadband services in the country. As per the rules and regulations of the license, the players have an option to provide service to upto 90% population in Urban areas and upto 50% Rural by 5th year and later on in modular approach to other areas.

Basili & Fontini (2003) in their paper stated that when an operator has the flexibility of implementation of technologies as a segmental process then it has implicit flexibility to launch new services in a sequential and discrete manner. Operator thus also has the flexibility to start off the rollout by a pilot project and then scale up the project according to the need and market response.

The various parameters in the Real Option are as below:

- **S** = The Present value of cash flows is calculated from the assumptions a will be explained in the next chapter. This is the output from DCF model.
- K = The Present value of capital expenditure required to rollout 4G/ Broadband wireless access services. This value is also explained in the next section.
- **t** = This is the time period over which the option may be exercised lest the telecom operators will lose competitive edge in the form of lost exclusivity or due to the rules and regulation decided by the concerned Government. In case of 4G/BWA auctions in India, 5 years from the time of allotment of the license has been fixed as the deadline for the partial rollout.
- $\mathbf{r_f}$ = This is the Risk free rate on 10 year GOI. The yield on 10 year GOI bond is 7.94% as of March[39].
- **σ** = The volatility of project returns. The exact volatility of the expected project returns is usually done using the Monte-Carlo analysis with relevant probability distributions of the input variables. In the absence of information about the relevant probability distribution, annualized standard deviation of returns of Bombay Stock Exchange Technology, Media and Telecom Index (BSE TECK) has been used as proxy which is equal to ~27.5%. It can be argued that the volatility of this project can be different from the one of the Index/ Industry but as standard industry practice this volatility value has been used.
- **q** = This is the opportunity cost of waiting and not rolling out 4G/BWA services. It is difficult to predict the exact pattern of cash flows to the firm as it depends on many external and internal factors that can vary differently from the assumptions made. Thus the exact loss by waiting to roll out 4G/BWA services is difficult to determine and hence it has been assumed that telecom operator plans to extract equal dividend yield = 1/T, that is 6.66% (T=15 years for 4G spectrum license) . That is telecom operator will be extracting 6.66% of the present value of the expected returns each year. This will be then the loss in case operator chooses not to deploy the network and wait.

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[39] http://www.tradingeconomics.com/Economics/Government-Bond-Yield.aspx?Symbol=INR, accessed on 10-03-2011

6. Data & Assumptions

In this chapter various assumptions have been explained along with their source. Also the reason behind the projections/ forecasts has been explained. The data discussed here forms the basis for the Discounted Cash Flow analysis later.

6.1 Population & Population Growth Rate

India's population was 1.15 Bn in 2009[40] and population growth has been declining from 1.7% in 2000 to 1.3% in 2009[41]. A population growth rate of 1.5% has been assumed for the next 15 years over the base of 2009 population. This growth rate assumption is justified by the planning commission's working paper which projects India's population growth from 1.51% to 1.39%[42].

6.2 Revenue Projections

Revenue projects can be done by separately projecting various drivers of the revenue. In telecommunications industry revenue is given by:

$$Revenue = ARPU \times Number\ of\ Subscribers$$

In this case subscribers are WiMAX subscribers exclusively but to arrive at the WiMAX subscriber figures, projections related to total broadband users, wireless and wireline mix in broadband and the proportion of WiMAX in wireless needs to be projected as can be seen below:

$$Revenue = ARPU_{Broadband} \times Subs_{WiMAX}$$

Where,

$$Subs_{WiMAX} = \%_{WiMAX} * Subs_{Wireless}$$

$$Subs_{wireless} = \%_{wireless} * Subs_{Broadband}$$

Thus we need to project four variables, namely ARPU from broadband, Total Broadband subscribers, % of broadband subscribers who will be wireless and percentage of wireless subscribers who will have WiMAX connection.

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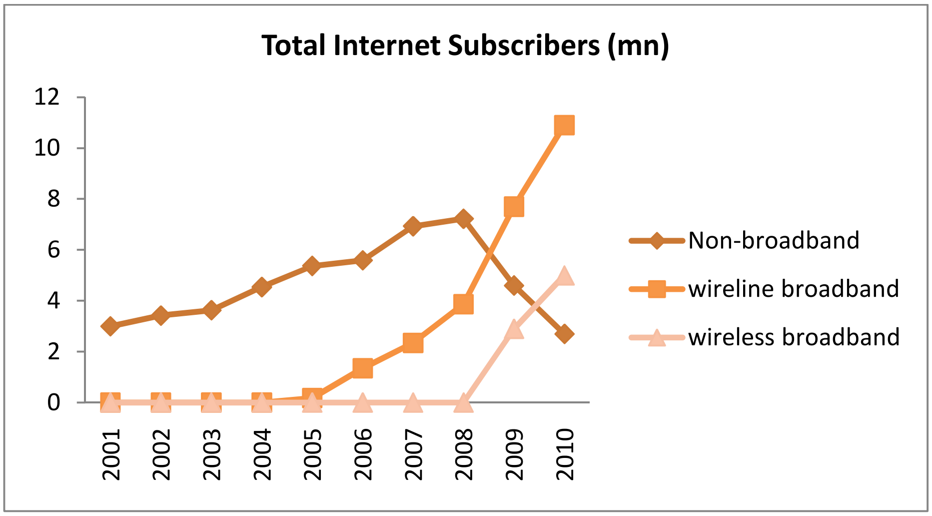
40 http://www.google.com/publicdata, accessed, on 10-03-2011

41 http://www.google.com/publicdata, accessed on 10-03-2011

42 http://www.planningcommission.nic.in/reports/wrkpapers/wp_hwpaper.pdf, accessed on 10-03-2011

6.3 Internet and Broadband Subscribers

As shown before and repeated here for clarity, India is experiencing growth in broadband connections and the broadband connection percentage among the Total Internet subscribers is increasing at an increasing rate. This trend in fall in non-broadband internet and rise in wireline and wireless broadband subscribers is expected to continue as per the trend seen in other nations.



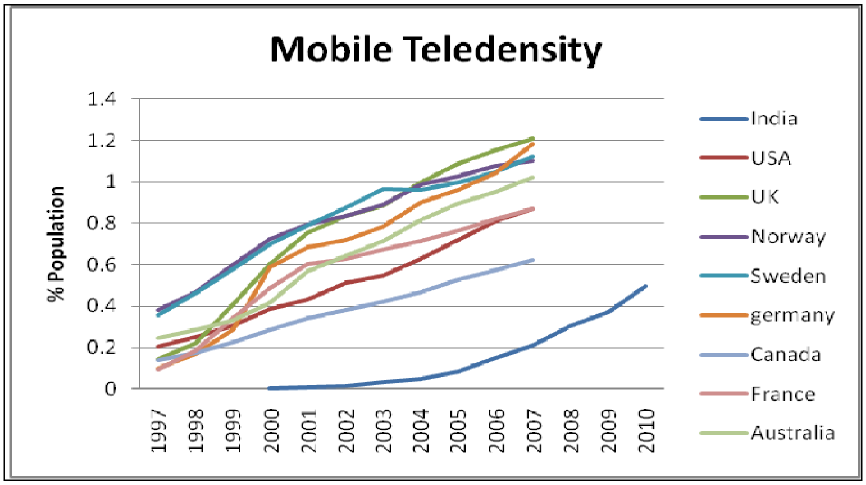
Source: CMIS Database

Figure 39: Historical Internet Subscribers breakup

Now the forecast for the broadband penetration and subscribers from year 2011 onwards was done. For this various research reports and article were consulted. The natural way to forecast a technology in a particular region is to compare the behavior shown to previous technology in the same region when compared to other regions as well as the behavior shown by the new technology in other regions. The forecast was done in two parts:

1) Through economic data and trend analysis
2) Through the forecasts by research reports

Reconciliation was done between data from both types of sources and the practical estimates were selected in the end. First the mobile tele-density trend was compared in India with other developed nations and the results are as shown below:



Source: OECD Database

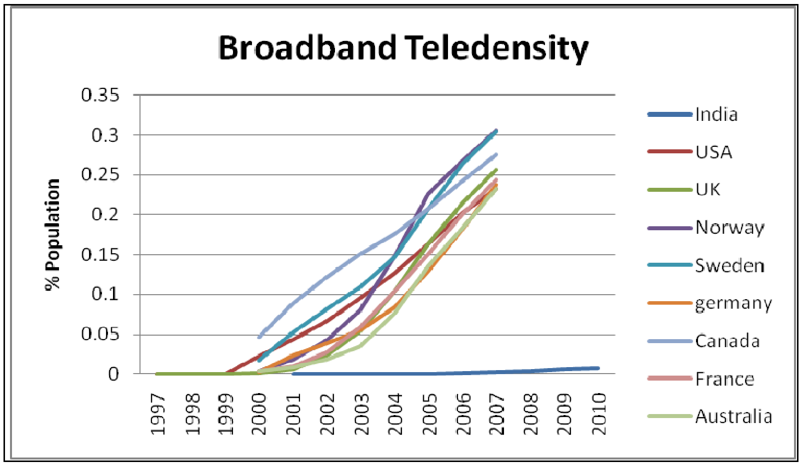
Figure 40: Historical Mobile tele-density

It was found that the tele-density in India is catching up fast and is taking the same trend as was seen in developed countries such as US and UK around 8-10 years back. That is the acceptability of the mobile technology has been similar even though with a lag of some years due to various reasons such as unavailability of affordable connectivity and technology. A view of mobile tele-density between US and India is as shown below:

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
US	0.20	0.25	0.31	0.39	0.43	0.51	0.55	0.63	0.72	0.81	0.87			
India				.00	.01	.01	.03	.05	.08	.15	.21	.30	.37	.50

Figure 41: Mobile tele-density comparison: US and India

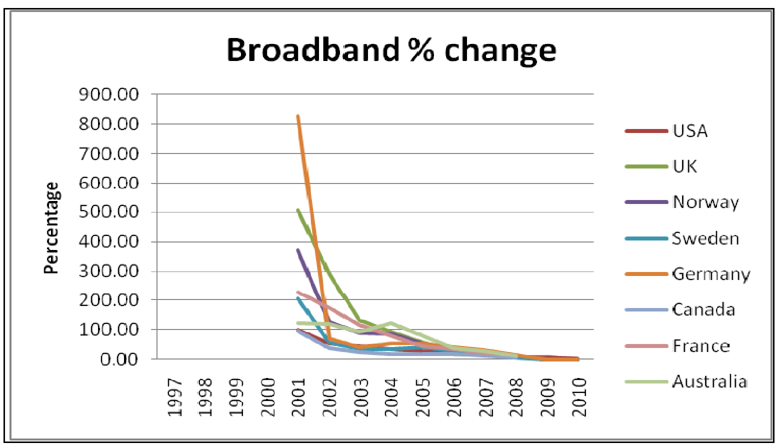
Next the broadband tele-density was compared and the trend was found to be similar, that is the tele-density of broadband in India is catching up fast with that of developed nations and the trend is taking similar path as we saw in developed nations and on similar lines as mobile tele-density. The tele-density of broadband is still very low < 1% and thus it is expected to increase at fast rate considering the auction of 3G and 4G spectrum.



Source: OECD Database

Figure 42: Historical broadband tele-density

Next the rate of change of broadband subscribers was considered and we found a general trend in all countries under analysis and with initial high increase in the subscriber the rate of addition tampered off. This is as expected as with more and more subscribers added, with time saturation is reached and unless a breakthrough technology comes the net additions keeps falling with time. The trend seen is as shown below:



Source: OECD Database

Figure 43: Historical broadband subscribers % change

Considering the facts mentioned above, the rate of growth of the broadband subscribers was forecasted on similar rate to the one seen in the developed countries and is as given below:

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
US % (historical)	100.18	54.96	44.61	34.63	29.78	25.10	15.90	10.17	8	2					
Year	2011E	2012E	2013E	2014E	2015E	2016E	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
India % (Forecast)	125.00	104.52	84.07	42.67	34.77	30.00	25.00	16.00	10.00	8.00	2.00	1.50	1.50	1.50	1.50

Figure 44: Broadband subscribers growth rate forecast

The rate of growth has been selected similar to the ones seen in developed nations. As the data is available till 2010 only and hence we got rate till 2021, that is for next 10 years and for the rest 5 years it has been assumed equal to the population growth rate expected in that period.

Next various Research report were consulted with an authoritative report by Aircel. This report assumes great significance as Aircel participated in Indian auction process and has won spectrum licenses in both 3G as well as 4G. The Aircel report[43] also tries to forecast the subscribers based on similar assumptions as shown earlier. In the report they predicted broadband subscribers starting 2009 till 2015. The broadband (wireline) subscribers have been predicted as 7.7mn in 2009 increasing to 10.9mn in 2010 and 69.4mn by 2015. The actual broadband subscribers (wireline) seen has been nearly 80% of the predicted ones, 6.22mn in 2009 and 8.7mn in 2010 and thus the rest of predictions need to be adjusted by 80% factor and the same adjustment factor has been retained on out total forecast of the broadband subscribers till 2025. In another report by TRAI, the estimate has been given for the total broadband users as 75mn and 160mn by year 2012 and 2014 respectively. The figures forecasted does reach the target by 2014 but misses the target by 2012 considering very low penetration at present and the previous forecast by TRAI also missed the actual subscribers in 2010 by high margins. Hence in long run forecasted values are concurrent with TRAI forecasts. Another report by Telcordia[44] forecasts total broadband users by 100mn by 2013 which looks achievable by the forecasts. A report by consulting firm Protiviti[45] again forecasts 100mn subscribers but by 2012, which definitely is not feasible considering the present scenario and the mark will be missed by at least 2 more years.

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[43] Aircel Report, "Recent trends in mobile data needs", 2010

[44] http://www.telcordia.com/news_events/media_coverage/express-computers-nov2010.pdf, accessed on 1/3/2011

[45] Protiviti, "WIMAX: The Quintessential answer to broadband in India", 2009

6.4 Broadband Penetration

The broadband tele-density forecasted on the basis of the forecasted growth rate of the broadband subscribers comes again similar to the developed countries. The tele-density is forecasted to be around 2% by 2011 and increase to 29% by 2020 and remain nearly constant thereafter due to the constraints in terms of the per-capita earnings and demographics. The forecasted tele-density of broadband subscribers can be seen below:

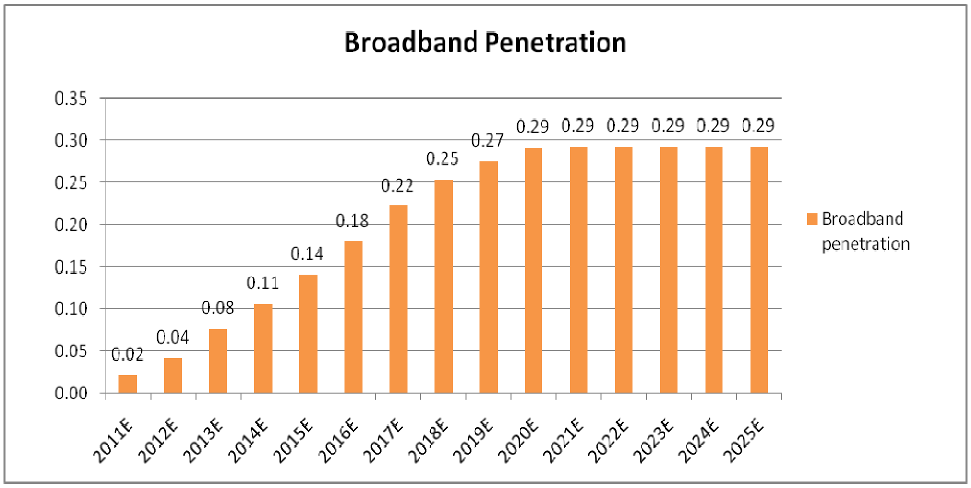


Figure 45: Broadband penetration forecast

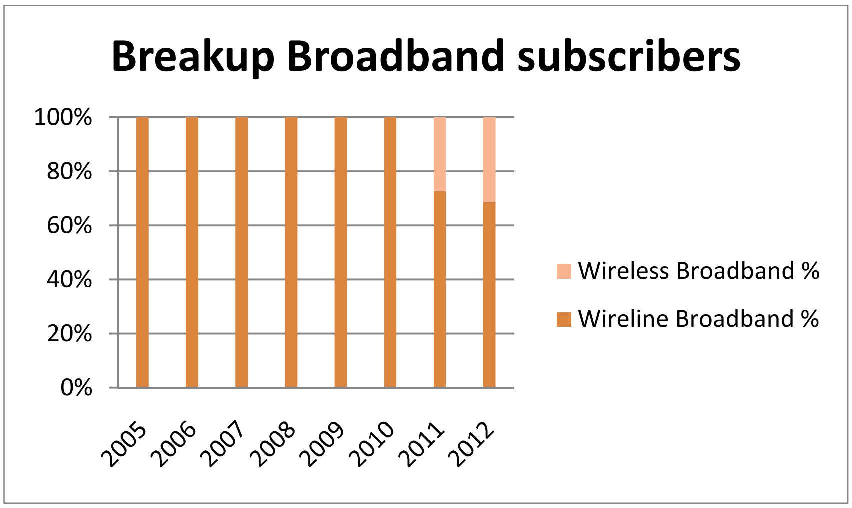
This is again as per the broadband penetration that has been reached by 2010 in various countries that varies from 23% to 30%. With a delay of 8-10 years the same penetration will be seen in India in terms of broadband.

6.5 Wireline and wireless broadband

Worldwide the majority of broadband users are either on DSL or cable, that is wireline broadband as they have developed and sophisticated network already present. In India and other developing countries the situation is different for example as in case of India most of the wiring for wireline telephone cannot support broadband speed. Only fraction of the wiring that does support broadband speed is mainly in urban areas that's too in Circle A. Moreover the cost of laying wire and giving access using wireline broadband is costly compared to providing access via wireless. As shown in HSBC report[46], there is not only cost differential between providing

[46]HSBC Report, "Indian Telecom", 2010

new wireline connection and wireless connection but also huge difference in ARPU in favor of wireless subscriber and hence any company will be better off giving wireless connection rather than wireline connection. Hence in future most of the growth in broadband is expected to be via wireless. In India, wireless broadband is being provided only since 2009 and so there is not much historical trend. Also as in developed countries wireless subscribers forms negligible portion and hence there is no historical data to rely on. As we can see since introduction of wireless broadband mainly by TATA and Reliance in un-auctioned spectrum the percentage of wireless broadband subscribers among total broadband subscribers is increasing fast. The data for wireless subscribers has been taken from Reliance report[47].



Source: Aircel Report

Figure 46: Breakup - Broadband subscribers

This trend is forecasted to continue and the proportion of the wireless broadband subscribers will increase as the marginal addition of new broadband subscribers will be more in wireless than in wireline. According to Aircel's projections the percentage of wireline and wireless are projected to change as given below:

Year	L+2	L+3	L+4	L+5	L+6
Wireline Broadband Subscribers	0.58	0.46	0.37	0.33	0.31
Wireless Broadband subscribers	0.42	0.54	0.63	0.67	0.69

Source: Aircel Report

Figure 47: Breakup broadband

[47] http://www.ril.com/rportal1/DownloadLibUploads/1276353679981_FPR120610.pdf, accessed on 1/3/2011

Where 'L' is the year when wireless broadband will be made available for subscription. Thus the report predicts a steady change in the composition of the broadband users. The same pattern has been followed and the change has been made constant at 30-70% breakup as even in long run it will be difficult to exactly have everyone on wireless technology due to the high ARPU for wireless and hence keeping the estimates on the conservative side the proportion of the wireline and wireless has been freeze at 2016 as shown below:

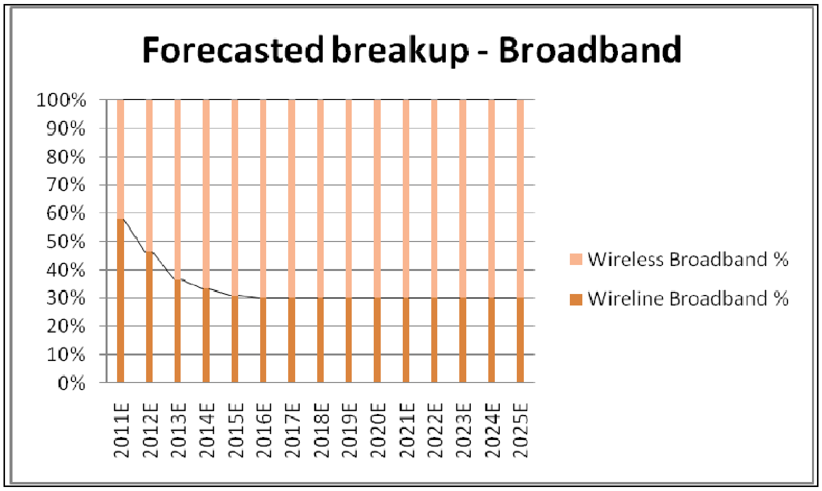


Figure 48: Forecasted breakup – Broadband

6.6 WiMAX Broadband subscribers

Next WiMAX subscribers need to be forecasted. Again there is similar problem of no historical data available either in other countries to compare to. Very few countries have auctioned spectrum for 4G technology application and thus there is lack of adequate research reports on other countries. As mentioned in chapter on broadband, 4G technologies are superior to all technologies present till now when it comes to broadband and thus it is naturally expected that it will be preferred over other technologies. As per the Reliance report, at present there are 0.2mn subscribers of WiMAX in 2009 and nearly 0.35mn subscribers in 2010. There are various reports by leading consulting firm and banks and an analysis was done of all the reports to reach a consensus figure for the WiMAX users according to the expected wireless subscribers. A report by FICCI titled "3G & BWA: The Next Frontier, Business Models, Projections and Imperatives" predicts 1mn subscribers in first year of availability and increases it to 10.8mn users by 5th year. If this data is used then it given 7% of the total wireless subscribers every year according to the wireline subscribers calculated in previous section. This proves that the underlying assumptions are similar in this report and the subscribers calculated above. But the WiMAX subscriber base cannot remain constant over time and should change in favor of WiMAX as most of the companies have taken WiMAX license and so should be launching in order to get returns over the price paid for the license. The HSBC report predicts 45mn users by the year 2016. The report by Telcordio is again wrong here as it predicts 60mn WiMAX users by 2013 which is not possible as the rollout is happening at present and so it cannot reach this figure in 3 years time. The report by FICCI predicts 28.5mn WiMAX and 4.9mn LTE subscribers by 2015 and a similar report by Protiviti predicts it as 80-90mn by 2019. Now to forecast WiMAX subscribers, the broadband subscribers of 3G will also need to be considered as 3G is also capable of providing high speed broadband and is wireless as well as already launched and thus have a first hand in terms of reach ability to subscribers. The only factor that will restrict broadband users using 3G will be the limited spectrum provided to telecom operators which will ensure that much of it is left for the voice subscribers. Also 4G technology once established will be more cost effective than compared to 3G technology. Hence the forecast of the WiMAX subscribers is done using all the data made available by the reports and has been forecasted as below:

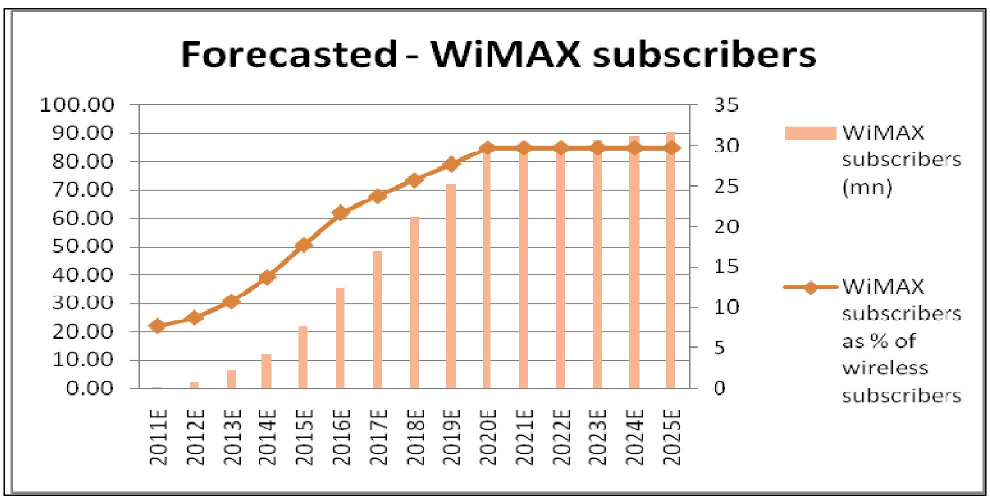


Figure 49: Forecasted: WiMAX subscribers

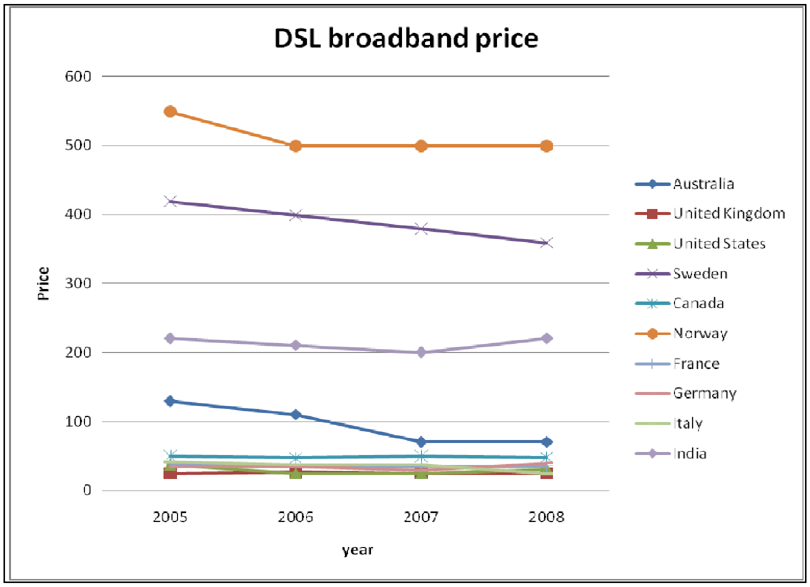
The underlying assumption is that the rate of the penetration of the WiMAX subscribers will itself increase with a rate of 1-4 % in coming years and will remain constant after 10 years, according to the initial assumption of broadband growth being stable after 10 years from now. The growth rate n the penetration of the WIMAX subscriber is given below:

2012E	2013E	2014E	2015E	2016E	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
1%	2%	3%	4%	4%	2%	2%	2%	2%	0%	0%	0%	0%	0%

Figure 50: Forecasted rate of growth in WiMAX penetration rate

6.7 WiMAX Broadband ARPU

ARPU for mobile broadband is around Rs. 700[48]. Penetration of broadband is very low in India and as there is not much history of broadband and thus the price war as seen in voice hasn't been seen in broadband and it has remained more or less same over the years.



Source: OECD Database

Figure 51: DSL Broadband Price

Hence it can be safely assumed that broadband charges will not fall much in coming years. Also the report by FICC also considers only a minor decline in 3G modem ARPU from $14.1 in 2009 to $13.3 by the end of 2013 which gives us a rate of -1.45% CAGR. A -1.5% drop annually till the end of 2020 has been assumed and then the ARPU is kept constant in the next decade. For 4G broadband revenue, the premium has been kept at zero over 3G broadband ARPU. The reason for same being that customer will not be able to differentiate much between 3G and 4G services at its end except for speeds and thus arbitrage will be created if there is any significant differential between ARPU from 3G services and 4G services and hence has been kept same.

48 http://www.bsnlevdo.in/bsnl-evdo-news/mts-to-offer-14-7-mbps-speeds-through-cdma-dongles, accessed on 10-03-2011

6.8 Operator's share in Data ARPU

The value chain of broadband and data which is provided over mobile mostly has 4 major players:

- Device Provider – Manufacturer of the mobile phone and other access devices
- Application Provider – Software vendors, game and application developers
- Content Provider – Content providers which the application uses
- Channel Provider – Telecom operator which facilitates and provides channel or bandwidth

Currently the share of data revenue is heavily skewed towards the telecom operators because of the limited uptake of data services in India for reasons mentioned before. Operator's share of the total data service revenue is expected to go down from the current 70-75% to 63-67% by the end of 2015 as per PwC report. This is bound to happen as when data services will uptake in the country supported by 3G rollout. In the DCF, a decline from 72.5% to 65% from end of 2010 to end of 2015 respectively and constant at 65% from 2016 to 2030 has been considered.

6.9 Capital Expenditure

Capital expenditure is Indian telecom industry can be broadly divided into two segments:

1. **Investment in Passive Infrastructure**
2. **Investment in License Fees**

In India investment in passive infrastructure is not done by telecom operators but by separate entities set up exclusively to maintain and provide passive infrastructure on sharing basis. Companies such as Reliance Infratel and Indus Towers are the two main providers of tower infrastructure on rental basis. The operators have to install their BTS (Base Transmission Station) according to the technology and density of the area. For 4G rollout the Investment in passive infrastructure has been calculated as given below:

For estimating the capital expenditure following methodology has been used:

Parameters	Values	Source
Total number of 4G subscribers by 2025	90406932	Forecast
Number of subscribers supported by a BTS	720-840 (Selected 700)	Protiviti Report
Number of BTS to be installed	129153	Calculated
Cost of one BTS	$10000-12000 (Selected Rs. 495000)	Protiviti Report
Total cost of installing passive infrastructure	Rs. 64576mn	Calculated

Figure 52: Passive infrastructure investment

This given per subscriber cost of installing passive infrastructure at around Rs. 700, which combined with Rs. 4277 paid for license, gives total capital expenditure per subscriber as Rs. 4995 which lies in the range Rs. 3000-5000 given by PwC report.

The second part of the capital expenditure is in the form of License Fees. Here license fees is the aggregate value paid by all the operators for acquiring 4G/BWA licenses in all the 22 circles combined which is equal to Rs. 385000 Million as per TRAI website.

6.10 Operating Expenditure

The breakup of the operating expenses for a typical telecom operator in India has been taken from a report prepared by FICCI in which they had given the industry wide cost structure with various heads.

Expense Head	Percentage	Driver
Net Interconnection Charges as % of Gross Revenues	20%	Gross Revenue
Network Operating Expenses	15%	Net Revenue
Sales & Distribution Expenses	7%	Net Revenue
IT Expenses	2%	Net Revenue
Service Expenses	3%	Net Revenue

Billing, Collection and Bad Debt	2%	Net Revenue
Marketing Expenses	3%	Net Revenue
Personnel Administration	5%	Net Revenue
Total Operating Expenses	37%	Net Revenue
Spectrum Usage Charge as % of AGR	3%	Net Revenue
EBITDA as % of Net Revenue	58%	Net Revenue
EBITDA as % of Gross Revenue	46%	Net Revenue

Source: FICCI Report

Figure 53: Operating Cost Structure in Typical GSM operator in India

6.11 Financing of Total Capital Expenditure

The total capital expenditure comes to around Rs 321.5mn and for financing such amount a debt equity ratio of 1 has been assumed. As valuation is being done considering it as a project and hence financing has been kept separate from the cash flows part and it has been assumed that the industry will maintain the debt and equity in the same ratio. The debt equity ratio is taken as the average debt equity ratio of 3 telecom operators for the last 5 years.

Year	2006	2007	2008	2009	2010	Average
Bharti Airtel	0.65	0.47	0.33	0.28	0.14	0.374
Idea Cellular	4.96	1.95	1.84	0.67	0.57	1.998
Reliance Communications	NA	0.71	0.82	0.6	0.48	0.6525
Average						1.00

Source: Moneycontrol[49]

Figure 54: Industry Debt Equity ratio

6.12 Depreciation & Amortization

For depreciation of capital expenditure and amortization of license fees a period of 15 years has been considered and straight line method has been assumed.

6.13 Cost of Capital

The formula to calculate Weighted Average Cost of Capital (WACC) is given as

[49] http://www.moneycontrol.com, accessed on 10/03/2011

$$WACC = K_e \times W_e + K_d \times W_d \times (1 - t)$$

Where,

K_e = Cost of Equity (Calculated using CAPM model)

K_d = Cost of Debt (Assumed to be 9% based on companies real cost in industry)[50]

W_e = Weight of Equity in Capital Structure (assumed 50%)

W_d = Weight of Debt in Capital Structure (assumed 50%)

T = Tax Rate (Assumed to be 30%, IT act)

Cost of Equity: Cost of equity has been calculated using Capital Asset Pricing Model given by

$$K_e = R_f + \beta \times (R_m - R_f)$$

Where,

β – This is measure of systematic risk of the project

R_f – Risk free rate of return (Risk free rate of return is considered as yield on 10 Year GOI bonds which is 7.94% in March-2011)

R_m – Rate of return on market (Rate of return on market has been calculated using Nifty 2010-2011)

βeta has been calculated using two methods namely:

1. Median beta of portfolio of the telecom companies
2. Weighted Beta of a portfolio of stocks of telecom companies with weights being given according to the market capitalization of the stock

Company (Stock)	Beta	Market Capitalization (Crore)	Weight in Portfolio
Bharti Airtel	0.73	122489	72%
Idea Cellular	1.06	20031	12%

50 http://articles.economictimes.indiatimes.com/2010-05-25/news/27573892_1_bharti-airtel-3g-third-generation-mobile-spectrum, accessed on 10-03-2011

Reliance Communications	1.52	18976	11%
MTNL	1.17	2753	2%
TATA Communications	0.53	6022	4%
Median Beta	**1.06**		
Portfolio Beta	**0.86**		
Sector Beta	**0.54**		

Source: Reuters[51]

Figure 55: Beta calculation

In order to have conservative forecasts, the highest value of 1.06 has been taken for the base case valuation. The WACC calculations performed are as given below:

Parameter	value
Debt-Equity Ratio	1
Weight of Debt	0.50
Weight of Equity	0.50
Cost of Debt	9%
Tax Rate	30%
Return on Nifty	
Monday, January 04, 2010	5232.2
Friday, December 31, 2010	6134.5
Return	17.25%
Cost of Equity	
Risk Free Rate on 10 Year GOI Bond	7.94%
Market Return on Nifty in 2010 CY	17%
Beta	1.06
Cost of Equity	17.80%
Cost of Capital	12.05%

Figure 56: Cost of capital calculations

[51] http://in.reuters.com/, accessed on 10/3/2011

7. Results

The result from DCF and Real option valuation has been presented in this chapter

7.1 Revenue Forecast

The forecasted Gross Revenue and the Free Cash Flow to Firm (FCFF) using the base case and the assumptions explained in previous chapter are as shown below:

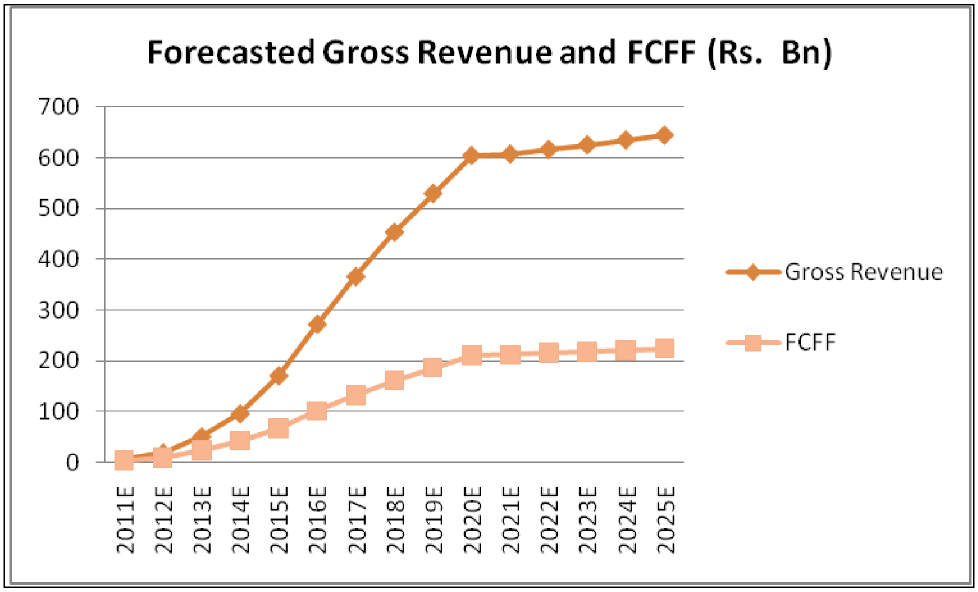


Figure 57: Forecasted Gross Revenue and FCFF

The gross revenue for the base case are forecasted to be Rs 643bn by year 2025, an increase from Rs. 6.6bn in year 2011.

7.2 DCF valuation

7.2.1 NPV and IRR

The NPV of the project after considering the license fees as well as capital expenditure comes out to be Rs. 221bn and IRR comes out to be 17.1%. The DCF model has been give in Appendix.

Method	Value	Selection criteria	Result
NPV (Bn)	221	NPV > 0	**Project should be accepted**
IRR	17.1%	IRR > WACC	**Project should be accepted**

Figure 58: Base case NPV and IRR

As shown, using either method as criteria, project consisting of 4G license purchase and network roll out should be undertaken by telecom operators to increase their shareholder value. The project looks attractive by both measures and returns are above the returns expected by market in the base case assumptions.

7.2.2 Sensitivity analysis

From the understanding of the DCF model, there are many critical factors which decide the outcome of the DCF and hence they need to be checked for the variance that can be seen in case the base assumptions are not met. These critical parameters has been selected as Subscriber adjustment factor, EBIDTA margin, Beta and Premium in ARPU compared to 3G broadband ARPU.

1. **Subscriber adjustment factor:** Subscriber adjustment factor is important parameter as it decides how many broadband subscribers will be there and decides if it will exceed or remain lesser than the projected subscriber base. Subscriber base forms one of the important variable in revenue calculation and hence is directly responsible for the DCF calculation. As shown below, ceteris paribus, NPV will remain positive even if the adjustment factor is made 0.5, that is half of the projected subscriber base and thus the project will remain viable even if the forecast of subscriber overshoots original subscribers. If the subscribers turn out to be less by 48% of the forecasted subscribers number (after adjustment value) then the NPV will become negative and the project will become unviable.

Sensitivity Analysis	Adjustment factor					
	0.48	0.6	0.7	0.8	0.90	1
NPV	-2	82	151	221	291	360

Figure 59: Sensitivity Analysis - Adjustment factor

2. **EBIDTA Margin:** EBIDTA margin has been assumed to be 47.4% in the base case but as 4G technology is new and there is lack of information among customers and hence in market like India, telecom operators might need to put extra expenditure in promotion

and marketing and might even need to push customers for high speed broadband. Besides as the technology is still to be scaled and hence telecom operators might need to incur extra expenditure in terms of the subsidizing device cost at the customer end. Thus overall effect will be to decrease EBIDTA margin and this can affect the NPV calculations. A scenario analysis has been done and EBIDTA margin has been varied from 50% to 40% to show how much variance can be seen in NPV resulting from different EBIDTA margin than expected. Here again as can seen form the output below, the NPV is still positive at 40% EBIDTA margin and hence it is robust enough to withstand variation in the margin. The reduction in NPV with reducing EBIDTA margin if not fast and so project can tolerate huge reduction in EBIDTA margins. If EBIDTA margins decrease to 30.3% or below, project will become unviable.

Sensitivity Analysis	EBIDTA margin					
	50%	47.4%	46%	44%	42%	30.3%
NPV	255	221	203	177	151	0

Figure 60: Sensitivity Analysis – EBIDTA margin

3. **Beta and Premium over 3G –** As shown before, the beta of the company and hence the project can vary from 0.54 on the lower side to 1.2 on the upper side and hence this can affect the NPV of the project. The scenario analysis has been done for pessimistic beta value of 1.2 to optimistic value 0.54 and the premium of 0% over 3G to up to 20%. As can be seen, again the NPV is very robust and remains positive for even reduction in the premium over 3G and increase in beta value. Keeping beta at maximum deterioration of 1.5, Premium over 3G should fall by 22.7% in order for project to become unviable.

Sensitivity Analysis NPV (Bn)		Beta					
		0.5	0.7	0.9	1.06	1.2	1.5
Premium of 4G over 3G	-22.7%	203	162	116	82	54	0
	-10%	299	252	199	160	128	66
	-5%	337	288	232	190	157	92
	0%	375	323	264	221	186	118
	5%	412	359	297	252	215	144
	10%	450	394	330	283	244	170

Figure 61: Sensitivity Analysis - Beta and premium over 3G

4. **Beta and EBIDTA margin –** The last scenario analysis has been run between beta and EBIDTA margin. Beta can change with time and can put increasing pressure in terms of the return expectations from the project and if combined with reduced EBIDTA margins can turn explosive. From the output shown below, it can be seen that NPV is again robust with simultaneous changes between EBIDTA margin and beta and can tolerate deterioration in both the parameters. Taking maximum deterioration in beta at 1.5, EBIDTA margins can fall till 36.5% before project becomes unviable.

Sensitivity Analysis NPV (Bn)		Beta					
		0.5	0.7	0.9	1.06	1.2	1.5
EBIDTA margin	36.5%	212	160	114	80	52	-1
	42%	301	242	190	151	120	59
	44%	333	272	217	177	144	81
	46%	365	302	245	203	169	103
	47.4%	388	323	264	221	186	118
	50%	430	362	300	255	218	147

Figure 62: Sensitivity Analysis - Beta and EBIDTA margin

7.3 Incremental Revenues for 4G Operators

As mentioned before, there can be two types of telecom operators who have taken licenses for 4G spectrum: Incumbent operators and standalone operators. For standalone new entrant in broadband services, there is no incremental revenue as it will be entirely new business line for it. For the incumbent operator there can be loss of revenue in its business related to non-broadband subscribers and wireline subscribers as well as 3G broadband subscribers. But as ARPU for 4G broadband is more than any other source of access to internet and hence no fall in final revenue is expected with switching from older technology to newer technology and hence there will be only incremental revenue and never a loss due to switching.

7.4 Real Option valuation

7.4.1 Real Option value

The value of the Real option was calculated according to the variables as explained in 5th chapter and has been given below:

Parameters	Value
S (Bn)	670.768
K (Bn)	64.6
r_f	7.94%
Q	6.66%
t (years)	5
Σ	27.5%
Output	**Value**
D1	4.2172589
D2	3.6023402
N(D1)	99.9987%
N(D2)	99.984%
License Value (Bn)	**437**

Figure 63: Real Option calculation

The value of optionality attached with the 4G spectrum is valued at Rs. 437bn which is more than the price paid by telecom operators that is Rs. 385bn. This shows that telecom operators have been cautious in the auction and have paid such that they still have up to 13.5% more value remaining in the spectrum. This is good news for telecom operators as they have received the spectrum with extra value above optionality value by 13%. This will give them extra space to execute managerial flexibility. From Government perspective, this 13% signifies the value that they could have earned as revenue over and above the amount received in auction. This points towards not so efficient auction process and the need to find better way to allow discovery of efficient price by supply-demand dynamics.

7.4.2 Sensitivity analysis

In Real Option valuation two parameters assume great significance, namely time to maturity and volatility. Now in Indian 4G auction process, the time to maturity has been fixed to 5 years by use of rules and regulations by DoT but it might be changed in future and so time to maturity will assume significance. Similarly volatility can change with time and hence can sway the value of option. The sensitivity analysis of both parameters in given below:

Sensitivity Analysis Real Option (Bn)		Time to maturity					
		3	4	5	6	7	8
Capital expenditure	64	498	467	437	410	384	360
	70	494	463	434	406	381	357
	80	486	456	427	400	375	351
	90	478	448	420	394	369	346
	120	455	427	400	375	352	331
	142	437	411	385	362	340	319

Figure 64: Sensitivity Analysis - capital expenditure and Time to maturity

The value of the capital expenditure should increase by 130% in order to make the optionality unviable at 5 years time to maturity and hence the optionality value is not very stable and in case of escalation of cost, telecom operators can go in loss easily and hence the auction has went more in favor of Government rather than telecom operators.

Sensitivity Analysis Real Option (Bn)	Volatility					
	0.275	0.30	0.45	0.50	0.60	0.70
Value	437	437	438	438	440	442

Figure 65: Sensitivity Analysis - Volatility and Real option value

The last sensitivity analysis will be done with respect to the subscribers forecasted and the adjustment factor in case it happens to change against the expectations. Again the same results can be see that is if the adjustment factor turns out to be little lower than forecaste then the value of optionality will decrease and will fall below Rs. 385 paid for the license and the telecom operators will be in loss.

Sensitivity Analysis Real Option (Bn)	Adjustment factor					
	0.4	0.705	0.8	1	1.2	1.4
Value	214	384	437	548	658	769

Figure 66: Sensitivity Analysis - Adjustment factor and Real option value

Overall as seen with the various sensitivity tests, it can be easily seen that telecom operators do have some optionality value left after the spectrum fees paid but if the underlying assumptions of the base case varies then it can lead to operators loosing on the margins and thus it can prove disadvantageous in the long run.

8. Conclusion and Recommendation

In this research, first analysis has been done of the country, here India and then the telecom industry. Indian telecom industry in one of the fastest growing telecom industry and boasts of its second position worldwide. Various reasons attributed to this growth have been explained in the report such as demographic changes, increasing affordability, favorable policies by Government etc. Recently held 4G/ BWA spectrum auction saw enthusiastic participation by the industry and even saw some new entrants in Indian broadband market. Government benefitted by Rs, 385bn that it earned as revenue from the auction of the spectrum and projected it as successful auction, one which generated maximum value for the nation. The report evaluates 4G spectrum, first as a project using traditional DCF valuation and later as spectrum license using Real Option valuation method in order to take into consideration the managerial flexibility and strategic decision making aspects.

The report tries to answer questions raised about the efficiency of the auction and the end value creation for all the parties involved. How will the players recover the license costs, along with the equipment and rollout costs? With the falling ARPU every year, will industry be able to earn enough to flourish or just survive or may be vanish under burden of the loan. In first step, DCF valuation has been done. During the analysis, broadband subscribers have been forecasted to grow from present 13.77mn to 544mn by the end of 2025. The wireless subscribers have been forecasted to be 70% of the total broadband subscribers after 5 years of roll out as it will be difficult to replace all wireline subscribers with wireless subscribers in India due to the high cost of wireless broadband and new technology. WiMAX is expected to increase its presence with time and reach 90mn subscribers from meager 0.35mn subscribers by 2025. The base case EBIDTA margins are supposed to be 47% and industry wide cost of capital as 12.05%. This forms the base case for the DCF analysis. The revenue has been forecasted using the subscriber number and the forecasted ARPU as Rs. 6.6bn in first year of roll out which increases to Rs. 643bn by 2025.

The Net Present Value has been found to be positive and comes to around Rs 221bn aggregate with an IRR of 17.1%. Thus 4G license as project is attractive proposition when compared to cost of capital as cut-off rate but considering that there are many risks associated with a new technology, the returns look nominal. The report further tries to analyse the risks associated with the base case and it has been found that there is less flexibility for the telecom operators and margins might get squeezed in long term. As a project, any telecom operator will like to have returns that justify the risk and time involved in the project. The License price reached during the 16 days of auction leaves 17% return under the base case assumptions. To probe this aspect further, in next step, sensitivity analysis has been done to analyse the risk associated with the assumptions and their effects on the NPV. It has been found out that if the subscribers turn out to be less by 48% of the forecasted subscribers number (after adjustment value) then the NPV will become negative and the project will become unviable. Also telecom operators will lose any positive NPV if EBIDTA margins fall to 30.3% from present 47.5% that is a fall of 33% in EBIDTA margin. If beta is kept at the most unfavourable scenario that is at 1.5 then project becomes unviable either if premium over 3G should fall by 22.7% or if EBIDTA margin falls to 36.5% or below. Thus there is very less space for maneuverability with telecom operators in terms of changes in the underlying assumptions of the base case.

Using Real option approach that takes into consideration the managerial flexibility and the value of strategic decision available with the telecom operators such as option to delay, option to choose technology, option to abandon after some time etc, the value of license has been calculated as Rs 437bn which is 13.5% more than the spectrum fees paid by the operators. Thus telecom operators have substantial value left after paying for the license fees and thus it has been bought as undervalued. This leaves telecom operators with excess value that they can use effectively as managerial flexibility. Where telecom operators have gained, Government has lost. This 13% surplus could have been garnered by Govt. if the auction process would have been highly efficient. This points towards the loopholes in the process which needs to be corrected. The gap between actual price that should have been paid and the lesser value finally paid can be due to telecos pulling out from auction process mid-way such as TATA and Reliance (led by Anil), lack of sufficient competitors, different industry view of risk with the new technology roll out with Indian subscribers or any other differing view compared to the base case. I future Govt. should try to make auction process more competitive and extract the maximum value as per the supply-demand dynamics.

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10. APPENDIX

DCF Model Projections

Year	2010	2011	2012	2013	2014	2015
Population (Bn)	1.18	1.20	1.22	1.24	1.26	1.27
Internet Subscribers (mn)	16.18					
Broadband Subscribers						
Total broadband Subscribers (Mn)	13.77	31	63	117	166	224
Total broadband Subscribers Adjusted(Mn)		25	51	93	133	179
Broadband Teledensity	1.2%	2.6%	5.2%	9.4%	13.3%	17.6%
Broadband Teledensity Adjusted		2.1%	4.2%	7.5%	10.6%	14.1%
Net Additions (Mn)		17	32	53	50	58
Net Additions Adjusted (Mn)		11	26	43	40	46
Broadband Subscribers breakup						
Wireline Subscribers	8.77	18.0	29.4	42.7	55.5	69.4
Wireless Subscribers	5	13.0	34.0	74.0	110.9	154.9
Wireless Subscribers Adjusted	5	10.4	27.2	59.2	88.7	123.9
Wireless Broadband Subscribers						
Wimax Subscriber	0.35	1.00	2.95	7.91	15.19	27.41
% Wimax Subscriber	0.07	0.08	0.09	0.11	0.14	0.18
Wimax Subscriber Adjusted	0.35	0.80	2.36	6.33	12.15	21.93
Wimax Broadband Users (Mn)	0.35	0.80	2.36	6.33	12.15	21.93
ARPU Projections (Broadband)						
3G broadband ARPU	700.00	690	679	669	659	649
Wimax Broadband ARPU	700	690	679	669	659	649
Total Revenue (Mn)		6615	19258	50785	96088	170774
Gross Revenue (Mn)		6615	19258	50785	96088	170774
Net Interconnection Charges		1,323	3,852	10,157	19,218	34,155
Net Revenue (mn)		5292	15406	40628	76870	136619
Operating Expenses (Mn)						
Network Operating Expenses		794	2,311	6,094	11,531	20,493
Sales & Distribution Expenses		370	1,078	2,844	5,381	9,563
IT Expenses		106	308	813	1,537	2,732
Service Expenses		159	462	1,219	2,306	4,099
Billing, Collection and Bad Debt		106	308	813	1,537	2,732
Marketing Expenses		159	462	1,219	2,306	4,099
Personnel Administration		265	770	2,031	3,844	6,831
Total Operating Expenses		1,958	5,700	15,032	28,442	50,549
Spectrum Usage Charge		198	578	1524	2883	5123
EBITDA (Mn)		3136	9128	24072	45546	80947
Interest		20231	20231	20231	20231	20231
Depreciation		29972	29972	29972	29972	29972
Amortization						
EBIT (Mn)		-47067	-41074	-26131	-4657	30744
Tax @ 30%		0	0	0	0	9223
Net Income (Mn)		-47067	-41074	-26131	-4657	21521
Add						
Interest		20231	20231	20231	20231	20231
Depreciation		29972	29972	29972	29972	29972
Amortization						
Substract						
Capital Expenditure (mn)	-64576					
License Cost (mn)	-385000					
Free Cash Flow (mn)	-449576	3136	9128	24072	45546	71724
NPV (Bn)	221					
IRR	17.1%					
Debt Schedule	224788					
Years	10					
Debt Remaining		224788	224788	224788	224788	224788
Interest	9%	20231	20231	20231	20231	20231
Depreciation Schedule	449576.38					
Years	15					
Asset Remaining		419605	389633	359661	329689	299718
Depreciation		29972	29972	29972	29972	29972

Year	2016	2017	2018	2019	2020
Population (Bn)	1.29	1.31	1.33	1.35	1.37
Internet Subscribers (mn)					
Broadband Subscribers					
Total broadband Subscribers (Mn)	292	364	423	465	502
Total broadband Subscribers Adjusted(Mn)	233	292	338	372	402
Broadband Teledensity	22.5%	27.8%	31.7%	34.4%	36.6%
Broadband Teledensity Adjusted	18.0%	22.2%	25.4%	27.5%	29.3%
Net Additions (Mn)	67	73	58	42	37
Net Additions Adjusted (Mn)	54	58	47	34	30
Broadband Subscribers breakup					
Wireline Subscribers	87.5	109.3	126.8	139.5	150.7
Wireless Subscribers	204.1	255.1	295.9	325.5	351.6
Wireless Subscribers Adjusted	163.3	204.1	236.7	260.4	281.3
Wireless Broadband Subscribers					
Wimax Subscriber	44.27	60.44	76.03	90.14	104.39
% Wimax Subscriber	0.22	0.24	0.26	0.28	0.30
Wimax Subscriber Adjusted	35.42	48.35	60.82	72.12	83.51
Wimax Broadband Users (Mn)	35.42	48.35	60.82	72.12	83.51
ARPU Projections (Broadband)					
3G broadband ARPU	639	630	620	611	602
Wimax Broadband ARPU	639	630	620	611	602
Total Revenue (Mn)	271714	365392	452740	528730	603086
Gross Revenue (Mn)	271714	365392	452740	528730	603086
Net Interconnection Charges	54,343	73,078	90,548	105,746	120,617
Net Revenue (mn)	217371	292314	362192	422984	482469
Operating Expenses (Mn)					
Network Operating Expenses	32,606	43,847	54,329	63,448	72,370
Sales & Distribution Expenses	15,216	20,462	25,353	29,609	33,773
IT Expenses	4,347	5,846	7,244	8,460	9,649
Service Expenses	6,521	8,769	10,866	12,690	14,474
Billing, Collection and Bad Debt	4,347	5,846	7,244	8,460	9,649
Marketing Expenses	6,521	8,769	10,866	12,690	14,474
Personnel Administration	10,869	14,616	18,110	21,149	24,123
Total Operating Expenses	80,427	108,156	134,011	156,504	178,513
Spectrum Usage Charge	8151	10962	13582	15862	18093
EBITDA (Mn)	128792	173196	214599	250618	285863
Interest	20231	20231	20231	20231	20231
Depreciation	29972	29972	29972	29972	29972
Amortization					
EBIT (Mn)	78590	122993	164396	200415	235660
Tax @ 30%	23577	36898	49319	60125	70698
Net Income (Mn)	55013	86095	115077	140291	164962
<u>Add</u>					
Interest	20231	20231	20231	20231	20231
Depreciation	29972	29972	29972	29972	29972
Amortization					
<u>Substract</u>					
Capital Expenditure (mn)					
License Cost (mn)					
Free Cash Flow (mn)	105215	136298	165280	190494	215165
NPV (Bn)					
IRR					
Debt Schedule					
Years					
Debt Remaining	224788	224788	224788	224788	224788
Interest	20231	20231	20231	20231	20231
Depreciation Schedule					
Years					
Asset Remaining	269746	239774	209802	179831	149859
Depreciation	29972	29972	29972	29972	29972

Year	2021	2022	2023	2024	2025
Population (Bn)	1.39	1.41	1.44	1.46	1.48
Internet Subscribers (mn)					
Broadband Subscribers					
Total broadband Subscribers (Mn)	512	520	528	536	544
Total broadband Subscribers Adjusted(Mn)	410	416	422	429	435
Broadband Teledensity	36.8%	36.8%	36.8%	36.8%	36.8%
Broadband Teledensity Adjusted	29.4%	29.4%	29.4%	29.4%	29.4%
Net Additions (Mn)	10	8	8	8	8
Net Additions Adjusted (Mn)	8	6	6	6	6
Broadband Subscribers breakup					
Wireline Subscribers	153.7	156.0	158.3	160.7	163.1
Wireless Subscribers	358.6	364.0	369.4	375.0	380.6
Wireless Subscribers Adjusted	286.9	291.2	295.5	300.0	304.5
Wireless Broadband Subscribers					
Wimax Subscriber	106.47	108.07	109.69	111.34	113.01
% Wimax Subscriber	0.30	0.30	0.30	0.30	0.30
Wimax Subscriber Adjusted	85.18	86.46	87.75	89.07	90.41
Wimax Broadband Users (Mn)	85.18	86.46	87.75	89.07	90.41
ARPU Projections (Broadband)					
3G broadband ARPU	593	593	593	593	593
Wimax Broadband ARPU	593	593	593	593	593
Total Revenue (Mn)	605920	615009	624234	633598	643102
Gross Revenue (Mn)	605920	615009	624234	633598	643102
Net Interconnection Charges	121,184	123,002	124,847	126,720	128,620
Net Revenue (mn)	484736	492007	499387	506878	514481
Operating Expenses (Mn)					
Network Operating Expenses	72,710	73,801	74,908	76,032	77,172
Sales & Distribution Expenses	33,932	34,441	34,957	35,481	36,014
IT Expenses	9,695	9,840	9,988	10,138	10,290
Service Expenses	14,542	14,760	14,982	15,206	15,434
Billing, Collection and Bad Debt	9,695	9,840	9,988	10,138	10,290
Marketing Expenses	14,542	14,760	14,982	15,206	15,434
Personnel Administration	24,237	24,600	24,969	25,344	25,724
Total Operating Expenses	179,352	182,043	184,773	187,545	190,358
Spectrum Usage Charge	18178	18450	18727	19008	19293
EBITDA (Mn)	287206	291514	295887	300325	304830
Interest	20231	20231	20231	20231	20231
Depreciation	29972	29972	29972	29972	29972
Amortization					
EBIT (Mn)	237003	241312	245684	250123	254627
Tax @ 30%	71101	72393	73705	75037	76388
Net Income (Mn)	165902	168918	171979	175086	178239
Add					
Interest	20231	20231	20231	20231	20231
Depreciation	29972	29972	29972	29972	29972
Amortization					
Substract					
Capital Expenditure (mn)					
License Cost (mn)					
Free Cash Flow (mn)	216105	219121	222182	225288	228442
NPV (Bn)					
IRR					
Debt Schedule					
Years					
Debt Remaining	224788	224788	224788	224788	224788
Interest	20231	20231	20231	20231	20231
Depreciation Schedule					
Years					
Asset Remaining	119887	89915	59944	29972	0
Depreciation	29972	29972	29972	29972	29972

DCF Assumptions

Year		2010 A	2011	2012	2013	2014	2015	2016	2017
Population Gowth Rate			1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Broadband Subscribers Growth Rate			125.00%	104.52%	84.07%	42.67%	34.77%	30.00%	25.00%
Broadband Adjustment Factor		0.8							
Wireline Broadband percentage			58%	46%	37%	33%	31%	30%	30%
Wireless Broadband percentage			42%	54%	63%	67%	69%	70%	70%
Wimax Penetration in wireless			8%	9%	11%	14%	18%	22%	24%
Wimax penetration growth				1%	2%	3%	4%	4%	2%
Current 3G broadband ARPU		700.00							
Decline in Wimax Broadband ARPU		-1.50%	-1.50%	-1.50%	-1.50%	-1.50%	-1.50%	-1.50%	-1.50%
Premium over 3G broadband ARPU		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cost of Capital	12.05%								
Net Interconnection Charges as % of Gross Revenues			20%	20%	20%	20%	20%	20%	20%
Expenses as % of Net Revenue									
Network Operating Expenses			15%	15%	15%	15%	15%	15%	15%
Sales & Distribution Expenses			7%	7%	7%	7%	7%	7%	7%
IT Expenses			2%	2%	2%	2%	2%	2%	2%
Service Expenses			3%	3%	3%	3%	3%	3%	3%
Billing, Collection and Bad Debt			2%	2%	2%	2%	2%	2%	2%
Marketing Expenses			3%	3%	3%	3%	3%	3%	3%
Personnel Administration			5%	5%	5%	5%	5%	5%	5%
Total Operating Expenses			37%	37%	37%	37%	37%	37%	37%
Spectrum Usage Charge as % of AGR			3%	3%	3%	3%	3%	3%	3%
EBITDA as % of Net Revenue			59%	59%	59%	59%	59%	59%	59%
EBITDA as % of Gross Revenue			47%	47%	47%	47%	47%	47%	47%
Tax Rate	30%								
Debt-Equity Ratio	1								
Cost of Debt	9%								
Rist Free Rate on 10 Yr GOI Bond	7.94%								
Beta	1.06								

Year	2018	2019	2020	2021	2022	2023	2024	2025
Population Gowth Rate	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Broadband Subscribers Growth Rate	16.00%	10.00%	8.00%	2.00%	1.50%	1.50%	1.50%	1.50%
Broadband Adjustment Factor								
Wireline Broadband percentage	30%	30%	30%	30%	30%	30%	30%	30%
Wireless Broadband percentage	70%	70%	70%	70%	70%	70%	70%	70%
Wimax Penetration in wireless	26%	28%	30%	30%	30%	30%	30%	30%
Wimax penetration growth	2%	2%	2%	0%	0%	0%	0%	0%
Current 3G broadband ARPU								
Decline in Wimax Broadband ARPU	-1.50%	-1.50%	-1.50%	0%	0%	0%	0%	0%
Premium over 3G broadband ARPU	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cost of Capital								
Net Interconnection Charges as % of Gross Revenues	20%	20%	20%	20%	20%	20%	20%	20%
Expenses as % of Net Revenue								
Network Operating Expenses	15%	15%	15%	15%	15%	15%	15%	15%
Sales & Distribution Expenses	7%	7%	7%	7%	7%	7%	7%	7%
IT Expenses	2%	2%	2%	2%	2%	2%	2%	2%
Service Expenses	3%	3%	3%	3%	3%	3%	3%	3%
Billing, Collection and Bad Debt	2%	2%	2%	2%	2%	2%	2%	2%
Marketing Expenses	3%	3%	3%	3%	3%	3%	3%	3%
Personnel Administration	5%	5%	5%	5%	5%	5%	5%	5%
Total Operating Expenses	37%	37%	37%	37%	37%	37%	37%	37%
Spectrum Usage Charge as % of AGR	3%	3%	3%	3%	3%	3%	3%	3%
EBITDA as % of Net Revenue	59%	59%	59%	59%	59%	59%	59%	59%
EBITDA as % of Gross Revenue	47%	47%	47%	47%	47%	47%	47%	47%
Tax Rate								
Debt-Equity Ratio								
Cost of Debt								
Rist Free Rate on 10 Yr GOI Bond								
Beta								