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Transition from Voice to Data – The Case of the Indian Mobile industry

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ABSTRACT

Over the past two decades, the mobile telecommunication industry has grown exponentially impacting not only the advanced countries but impacting developing countries too. A lot of research is going in the field of Mobile Technology. However, emerging markets like India are relatively understudied. Advanced technologies are getting developed and deployed. Increasing competition is the order of the day. The knowledge about the technology introduction, the characteristics, evolution and adoption that is bringing in the transformation in the Mobile Telecommunications industry is studied through the Lyytinen & King 92002) framework incorporating the ingredients-Institutions, Market, and Technology..This paper analyses the Indian mobile telecom scenario by segmenting the growth of the industry in three phases since the introduction of Mobile telephony in the country in 1994 - the initial phases, more competition and growth and the onset of mobile broadband. The interplay between various technologies, the service providers and the role played by the government and regulators keeps on taking various hues in the dynamic world of mobile telecom industry

Keywords: *Evolution, technology, mobile, wireless, India, developing country*

1. INTRODUCTION

Times new Roman
12pt All CAPS

The Telecom industry in terms of sheer numbers of subscribers is moving ahead in quantum leaps. From a dismal Tele density of 0.99 in 1994 to a tele density of 78.66 in the beginning of 2012, India has moved a long way. The numbers speak of themselves in this remarkable growth story. The engine of growth is clearly wireless technology since it took over the batons in the Telecom technology domain in 1995. What the wire line industry acquired from the time landline phone was started in 1890 in India; the wireless industry in the span of 10 years starting from 1995 matched the landline numbers in 2005 and from that year the chasm between the subscriber numbers of the two systems show an increasing pattern of divergence. Where acquiring a phone connection needed a connection in the right places in the pre mobile era, taking on multiple connections in a household is the norm now. A typical family in urban areas would have at least one mobile connection for every family member including teenagers and school going kids. This might be combined with a broadband connection. The situation in the hinterlands is yet to achieve the high penetration and usage levels as in urban areas but nonetheless the growth story continues in spite of the difficulty of rolling out telephone networks in the vast geographical disparate terrains of the country where accessibility, climatic vagaries and awful electrical power supply issues predominate. This shift has clear connotations in the overall growth of the country.

May 2014	Total	Wire line	Wireless
Subscriber (Million)	938.34	28.18	910.16
Urban Subscriber (M)	556.25	22.31	533.94
Rural Subscriber(M)	382.10	5.87	376.22
Tele density	75.51	2.27	73.24
Urban Tele density	145.56	5.84	139.72
Rural Tele density	44.40	0.68	43.72

Source: Telecom Regulatory Authority of India

The wireless industry since its birth in the country started with primarily offering voice services. Voice is the major service which is driving the usage of the networks with a smattering of other services led by Short Messaging Services (SMS). Data usage in terms of internet access was introduced in 2004 when GPRS/EDGE service as an upgrade of GSM was offered to the subscriber. The growth in data in the initial years has been sluggish and the primary driver of usage has been voice as yet. The usage at least in the urban areas is slowly starting to show some numbers with the advent of new and speedier mobile technologies, proliferation of smart phones and increasing usage of social portals and the like.

Wireless Technology for the uptake of data services is available and for the service providers there are several alternatives to take the momentum forward: GPRS/EDGE, WCDMA, and HSPA from the 3GPP family of standards while CDMA EVDO from the 3GPP2 family appears to be the main choices. Both the strands converge to a common standard LTE. Other non 3GPP technologies that operators are looking at are IEEE 802.11 Wi-Fi and 802.16e WIMAX. Some of these technologies are coexisting in the existing market place while in the BWA front LTE seems to be taking the early lead compared to WIMAX as made out from press statements on the industry and early commercial rollouts.

Several wireless technologies are currently serving the end customers. Some service providers like BSNL have also launched WiMAX to reach their subscribers. Newer technologies are looking to make inroads in the country some of which are upgrades of existing technologies while the others are newer avatars in form of LTE, Wi-Fi, and Near Field Communication (NFC) etc.

The wireless access situation is piquant to say the least in terms of expectations from operators and the government. The end user requirement is somewhat far off as the initial 3G numbers for data seem to indicate. 3G networks have been launched by all major operators with the first launch in 2008 by the state public sector units MTNL for Delhi/Mumbai and

BSNL for the rest of the country. The private operators followed suit once the 3G auctions were completed and spectrum was allotted. 3G in terms of higher speed is offered from the stables of major operators like Airtel, Vodafone and Aircel following the 3GPP (3rd Generation Partnership Project) family while service providers like MTS, Tata and Reliance offering data plans with the 3GPP2 family of offerings. Some of the operators are having offerings from both the 3GPP and 3GPPs family of technologies.

With the private operators like Airtel launching wireless networks in 1994 from Delhi with GSM technology and government public sector operators following suit in 2001/2002 India has come a long way in terms of subscribers, technology and customer expectations. When GSM was launched in the early years it was primarily voice for which the networks were designed. With Smart phones and Android operating systems, Blackberry and Apple phones, the trends in India are showing similar trends shown in other global markets. But this usage is more restricted to the cities where internet browsing, emails, social portals and enterprise traffic is being carried on the data networks. Other applications which can bring more data traffic flows are yet to see light of the day. Few applications like Mobile TV, Streaming etc. have not shown much usage requirements. But smart phones can play the role in enhancing data traffic provided the tariff and handset cost become affordable to the common user along with the right applications. End user devices like Tablets especially low cost and workable ones does seem to hold promise to enhance the data traffic scenario.

Availability of the technology is not the sole criteria for success of data services leading to Mobile Broadband. Technology' success in the market place is dependent on host of favorable factors- government policy, spectrum, regulation, operators, market, end users, end terminals, pricing, availability of coverage, quality of connectivity to name a few.

The journey of Indian Mobile telecommunications can be described in the following phases of evolution in time:

1994-2002: Initial phase of Mobile telephony with voice services
2003-2008: More competition and mass penetration with advent of data services

2009-onwards: Onset of Mobile Broadband

There is a push and pull from several actors in the ecology of wireless technology and the intent of this paper is to throw some insight into the different players in this complex web of technology, economics and social forces that would drive the uptake of mobile data/broadband in India. The paper will try to answer the following

- How has the Mobile industry moved since its inception in the country?
- In what periods of time has the shift happened?
- Why has the changes taken place in the way it took place?

SECTION 2: LITERATURE REVIEW

The literature in the context of Telecom in India is quite rich. A number of papers have been written on the Telecom policy in the country.

3G & 4G
S. Singh et al (2010) analyzing the Indian market for 3G services through a revised TAM model expect that the future looks promising for the 3G services in the country. The paper by P. Makam considers the upcoming 4G services from a researcher's point of view on the challenges, applications and services

Broadband
Broadband has received a fare share of attention with R Jain & R. Dass (2011) listing out a number of recommendations for a national broadband policy considering the importance of the sector and argues for a more active role of the government. Wireless broadband is delved into by A. Jhunjhunwala & A. Aiyar (2007) looking at the prospects of technology and challenges in rolling out broadband wireless to the hinterlands where majority of the population resides with a particular case of wireless broadband penetration in Uttar Pradesh touching on the governance and regulatory issues

Diffusion
V. Sridhar (2006) and S.K. Singh (2008) delves into the mobile penetration in the country with Sridhar proposing a mathematical model to forecast penetration and bringing into focus the relative penetration of mobile services in a big geographical area like India and the disparity that exists between the subscriber numbers in the urban and rural areas. Singh (2008) states that the mobile phone diffusion in the country would continue till the years 2012-2013.

Financial
The Indian stock market does not have too many operators or major Telecom vendors listed in the NSE, or BSE. A paper by Mohan Raj K.et al (2011) on the Finances with the behavior exhibited by 10 Indian telecom companies in the Stock market when the 2G scam hit the sector finds the share prices of all of the studied companies declined in the aftermath. The prices on an average showed to be healthy before the scam broke.

General
Benefits of access to the internet are great enough so government should employ a strategy similar to the community telephones to India's villages. This can include improving affordability through a competitive environment and encouraging the use of radio technology in bridging the digital divide in the country (T.H.Chowdary, 2002)

Growth
A vision of the Telecom sector is presented by Manas Bhattacharya (2003-4) for the year 2020. For the journey ahead to that objective and based on international experience, the agents of change are highlighted in the vision paper prepared for the Planning Commission.

Licensing

The paper by Stephen D.Mcdowell, Jenghoon Lee (2003) argues that each of the licensing approaches undertaken in India represents a political and regulatory bargain among interested and powerful groups in India's telecom sector sharing the view by Mody (1995). The regulatory policies adopted shows a shifting stance ever since the liberalization policies started in the country up to the start of the start of the next decade of liberalization and this shows up in the spectrum issuance. P. Sinha & A. Gupta (2011) analyses the BWA auction India held in 2011 through the real option methodology and puts the view that the value of license is 437 Billion rupees which is more than 13.5% of the spectrum fees that was paid by the operators. This is a loss for the exchequer as the auction could have been engineered to extract maximum revenue. The auction saw active participation even by new players ready to invest in the sector.

Market

S. Biancini (2010) analyzes the demand and supply side of the telecommunication market in India considering the Universal access policies and finds that for mobile telecom there are indications of substitution effect in urban areas while seeing a positive network effect in the low penetration areas of the country.

Mobile Broadband

The driving forces for mobile broadband technology development are not comparable for different areas/countries as conditions in terms of political, economic and regulatory circumstances are not same. Developing countries like India will have to work out their own solutions for mobile broadband unlike the steps taken in Europe. (J. Markendahl & B. Molleryd, 2012)

Operator

Reliance Infocomm is one of the few operators who launched their mobile services with CDMA technology and eventually also took up the 3GPP technology of GSM. The firm created a splash with the “Monsoon hungama” with the first of its kind offer in the Indian mobile market. Sangeeth Varghese (2007) traces the case of Reliance Infocomm which set off a trailing blaze in the Indian mobile market and shook the incumbent operators through a series of well crafted strategies of marketing, pricing, cost structure, product design, distribution and advertising. Reliance helped in shifting the penetration of mobile from the topmost segment to the masses through a new strategy which was simple but very effective in the Indian context. BSNL which is PSU having nationwide presence in wire line and wireless services is another operator getting attention. V. P Tanguturi & F.C. Harmantzis (2006) analyses on the 3rd generation wireless technologies available to the operator with alternatives and possible migration paths.

Policy

Telecom Policy in India is replete with its twists and turns since the liberalization moves started in the early nineties. This is touched upon by several papers (R,Subramanian (2008), J. Srinivasan(2010), H.V. Singh et al (2003). The Indian telecom reform process is influenced by different interest groups with the department of telecom (DOT) opposing reforms and trying to hold on its age hold hegemony. The Indian state has moved from a state of telephone as a luxury to a state where the policy calls for affordable service access for all (J.Srinivasan). The paper by H.V. Singh et all gives a perspective on the multitude of issues that impact policy. -1) Interconnection 2) Tariff where rebalancing is needed.3) Convergence: The distinction between the telecom and broadcasting world is diminishing by the day 4) Technology 5) Consumer Welfare which is the heart of the telecom revolution in India 6) Competition 7) Regulatory: Reform measures undertaken in the country were on hindsight seen to be without a much thought out strategy. They argue that hasty policy decisions are to be cautioned as the policy decisions taken by developed countries may not exactly fit the Indian scenario.

S. Gupta (2011) traces the mobile growth in India weaving through the policy and regulatory issues. He argues that although growth in numbers has taken place in the country, the Mobile sector’s performance is still much to be desired .The competition among the operators seem to be in place for the coming near times although issues related to governance continue to plague the industry

Reform

M. Hossain & R. Kathuria (2004) in their paper analyses the reforms taking place in the Indian telecom scenario in the "new economy" which is enabled by IT and growth in the telecom sector. The authors’ point that though reforms in telecom in the starting years were riddled with jerks, growth continued in the sector with market based services being introduced in the sector with consultations by the regulator with different stakeholders. They are of the view that in a market driver scenario, the regulator should not be overbearing in the sense that it should be more focused in creating a growth friendly environment.

Regulation

Regulation has its own importance in the growth of telecom services. S.Jain (2008) focuses on the regulatory scenario in a number of Indian sectors including telecom The travails of the telecom sector covering the major regulatory issues that have come since the TRAI came into being are analyzed - Reliance mobile -WLL, introduction of CPP regime, ADC regime, Reliance ADC theft, Tata SUN TV dispute and roaming with the decisions of federal telecom minister A.Raja in the sector. Jain argues that the regulatory uncertainty has its costs in building infrastructure albeit at a greater cost. R .Jain (2004) in her paper on touches two critical aspects of telecom sector growth in India- tariff rebalancing and Interconnections , the proper handling of which by the authorities leads to healthy competition and fuels further growth. The author is of the view that the role of the regulator was seen to be wanting in this respect as TRAI was seen to take a back foot and seen to endorse the incumbent government PSU stand . This also sent the wrong message that although technological neutrality was the driving paradigm it's decisions do not seem to highlight the policy stand. K.Dash (2005) takes the case of deregulation of government owned enterprise in India with the example of the Telecom sector with changes that have taken place over the period-1985-2005 which heralded the telecom revolution in India. The paper traces the Stop-Go model of reform in Telecom in India and argues that changes were impacted not

by the government in power which is the driver in the process but also by multiple scenarios and players like government in power, coalition government push and pull, opposition, trade unions and business players. It looks at the evolution through the veto power theory. The paper lends support to Tsebelis's contention that in a parliamentary democracy the reform process like deregulation will be incremental due to many veto players in action and that non political players like courts and bureaucrats have a major say in the process.

Regulation and investment

The role of the Indian regulator in terms of its effectiveness covering the parameters of market entry, spectrum, interconnection, tariff regulation and anti competitive intervention is the focus of study by P.Malik (2004). Considering the intricate conditions where the regulator had to fend itself with the incumbent, DOT and the legal system, the author opines that regulator during its short history from its inception in 1997 has played a role especially well in the tariff regulation aspect. Considering that the thrust of the government is more telecom penetration, TRAI has to balance its role in its regulatory aspect with the development consideration in mind.

Services

A Dutta & V. Sridhar (2003) in their paper on Mobile services growth in India looks at the competition in the wireless industry and how it is impacted by the feedback from one carrier to another and the environment by taking a systems dynamics approach. J. Fernandez & R.K. Kakani (2006) dwells on the emerging VAS market in India for wireless systems. They posit that the market is highly fluid but is bipolar between content aggregators and network providers. One space to watch out for would be the media industry which has got rich content. On a forward note they put the argument that once internet access comes on the mobile the role of MNO would diminish.

Spectrum

Spectrum in India has received a lot of fair amount of scholarly attention in the research field. Rohit Prasad & V .Sridhar (2009,2011) , C.S. Rao (2009), Ankit Mittal, R.S. Jain (2001), V Sridhar & others (2011) , D Lewin et al (2008), A. Kumar (2011) . V. Sridhar & R.Prasad (2011) looks at the issue of spectrum policy in India and considering the multiple players jostling for more of the scarce resource, the authors come up with a series of recommendations that calls for secondary market activity in spectrum, delinking current policy of licenses from spectrum with licenses issued for long term, allowing any allotted spectrum to be used for the most effective technology and services without restricting it for 2G, 3G use etc. The paper also asks for a Information registry for information on spectrum holders so that efficient trading can take place with requisite information available to determine value and advocates that the process of allotting additional spectrum based on SLC be withdrawn .They posit that allocative efficiency of the mobile industry is a more appropriate policy measure and illustrates absence of the same in Indian mobile industry. C.S.Rao (2009) argues for considering good global practices and learning's with the authorities aim towards maximizing the general social welfare rather than go for revenue maximization to the government coffers. A. Mittal (2007) advocate that future spectrum and licenses should be allotted in a technology neutral philosophy, Defence spectrum need to be reworked, possibility of using 900 MHz for 3G and spectrum refarming. R.S.Jain (2001) critically comments that in spite of India being one of the early adopters in spectrum auction, the country has not realized the benefits that should have accrued out of the same.

From a mobile broadband perspective with increasing data and internet traffic, V.Sridhar et al (2011) suggests for secondary markets in terms of spectrum sharing, mergers, spectrum trading and dynamic access sharing.

Standards

Given the importance of communications in today's world its spread in developing economies is critical for their development. Emergence of standards reduces market and technological uncertainty and lays the foundation for market creation. A variety of approaches to standard adoption exist (R. Basant, G.R.Ramadesikan, 2002). The authors advocate standard neutrality for the country at this stage as a large and growing telecom market in India can support such a strategy without compromising economies of scale.

Technology

The role of Technology in the telecom expansion in a country like India has its due importance with Indian products and low access tariffs (A.Jhunjhunwala, B.Ramamurthi & T.Gonsalves, 1998) while L.F.Pau & J.Motiwala (2007) analyzing different adoption models propose that India is a case of fragile adoption and deployment in the wireless domain

Country comparison

A cross country comparison between India and China on telecom evolution has been presented by Chun Liu & Krishna Jayakar (2012). Their paper gives a perspective on the policy making process in China and India taking one case study in each country and suggests that the present process of policy making has lots of areas for improvement. Walter Baer et all (2011) focuses at the issue of openness in wireless networks worldwide focusing on some key markets in America, Europe and Asia including India and takes the view that the issue of openness becomes relevant as it has helped develop innovative features and functionalities in the internet. Keval J. Kumar & Amos O. Thomas (2006) brings into focus the similarities and differences between the two fastest growing economies with a huge population base-India and China. They argue that mobile telephony is not the panacea that is touted to bringing about social change

SECTION 3: RESEARCH FRAMEWORK

Lyytinen and King (2002) put forward a model to show the various forces in play in a mobile ecosystem following the actor network theory as postulated and advanced by Bruno Latour, Michel Callon and John Law. Lyytinen and King has proposed a framework to capture the inter relationships between innovation system, market and regulatory regime to understand the interplay between them leading to the transformation taking place in the wireless networks. A

number of works using this framework has come up studying the mobile ecosystems in countries such as USA, UK, China and Korea. This framework provides a holistic view of the actors interplay in the development of mobile systems. Although a number of studies of the Indian telecom and mobile systems covering different aspects as spectrum, policy, diffusion, regulation are there, a study of the Indian mobile environment covering the different aspects as postulated by Lyytinen and King is a gap that needs to be plugged. This paper is an endeavor to study the Indian Mobile industry taking into aspect different actors who matter in the success or failure of the next stage of evolution of mobile technology and services from voice to mobile broadband.

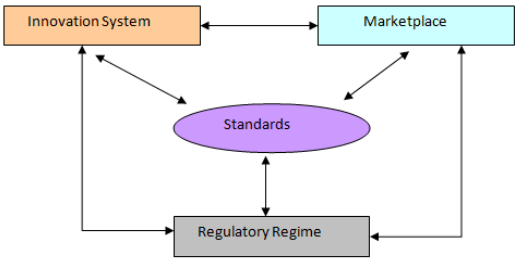

Figure: Wireless Industry's Institutional Environment (Lyytinen & King, 2002).

Innovation System:
The interlinked network of site, competencies, ideas and resources which are capable over time of developing novel technologies and solutions (Tilson & Lyytinen, 2006)

Market System:
Set of actors that produce telecommunications services and technologies (within a value network) exploiting the technological potential within telecommunications standards or technical innovations (Tilson & Lyytinen, 2006). Market trends such as increased customer innovation and creativity and social networking mean that customers are now active participants in the creation, evolution and development of a firm's offerings (Berthon et al. 2007)

Regulatory Regime
Any type of authority (industrial, national, international) which can influence, direct, limit or prohibit any activity in the innovation system, the marketplace or the regulatory regime itself . (Tilson & Lyytinen, 2006).

Standards:
Standards are set at the centre and viewed as central to coordinating the activities of the regulation of the marketplace and associated innovation system within the wireless industry. The evolution of wireless services is critically dependent upon the creation and implementation of intra and inter system standards (Lyytinen & King 2002)

3.1 Studies where the Lyytinen-King framework has been used

The success factors leading to the wide acceptance of 3G in Korea is in marked contrast with most other developed countries. H Yang et al (2005) analyses the forces that play a pivotal role in the diffusion of a complex technology like wireless broadband which gets accepted by using the Actor Network Theory (ANT) and drawing on the Lyytinen and King framework on complex technology system innovation in a dynamic role The Korean market is studied by breaking the time period into different phases to study the evolution in terms of technology, market and regulatory regimes.

B. G.Lee et al (2009) look at the 3.5 G scenario unfolding in South Korea. Data service is picking up in Korea as operators look for new revenue models as voice market is getting saturated. The authors opine that in face of three 3.5 technologies- EVDO Rev A, HSDPA and WiBro which are deployed in the country it is still early to predict who will emerge as the ultimate winner although the government is doing its bit in promoting the home grown WiBro technology. The development of the wireless standards is looked at from the Lyytinen-King framework.

Y.Yoo et al (2005) studies the role of standards in the diffusion of wireless broadband in Korea through the ANT theory and the Lyytinen and King framework. The success of mobile broadband telephony in Korea is due to the harmonization of the different actors in the framework where the role of standards is paramount among the participating forces and their varied interests. Although individual elements such as social and cultural aspects might contribute to the success in Korea, it is pertinent to study the inter relationships of all elements over time and the evolving alignment between them

The research framework by Fomin and Gao (2005) intends to find out the transition towards 3G in the Nordic region and test whether the resolution of reverse salients which can be attributed for the slow take up of 3G in Europe is critically dependent on the availability of standards as postulated by Lyytinen and King.

D.Tilson & K.Lyytinen (2005) through an actor network angle looks at the changes in the US wireless industry from 2G to 3G and opines that it is more than a simple technology upgrade. Transition to 3G is a major economic transformation and requires a major reconfiguration of the value network bringing many more new players. Technical standards will be essential to the effective operation of wireless systems.

Tilson (2005) in his thesis "Standards Making and Adoption in Complex Socio-Technical Systems" through interviews with key stakeholders as a primary tool compares the US and UK wireless scenario and posit that standards have a stellar role to play when actors align their positions to implement a complex technical system like the wireless industry. The introduction and development of a new concept in wireless communications CR-Cognitive Radio is analyzed by (V V.Fomin et al, 2011) and contend that each stakeholder could help or retard the development and commercialization of a new technology .Using the Lyytinen and King framework, J.Damsgaard & C.Kelleher (2007) agrees with the model proposed and argues that for understanding the diffusion and adoption of mobile services , studies of factors in isolation serve no purpose and the complex equation between different forces need to be taken in a holistic manner. They have taken

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the framework to analyze four different accounts of mobile phone diffusion. Sylvia Elaluf- Calderwood et al (2011) considers the Lyytinen –King tool in studying the tussle between the interests of different stakeholders in a scenario where internet and mobile telecommunications infrastructures is getting converged. They analyze this complex relationship through a "control and tussle" framework.

Indian mobile communications is chosen for study with the Lyytinen & King framework because of a number of compelling reasons. First, India has seen healthy growths for the last 15 years of mobile subscriptions that have few parallels other than China in terms of subscribers. This huge subscriber base with various operators and technologies can prove to be an apt domain for study of evolution to mobile data. Secondly, as studies in other actor network studies and King- Lyytinen (2002) framework have shown are primarily of countries which have a telecom manufacturing base. USA, Japan, China, Korea and EU (Sweden, Finland, France) all have mobile technology manufacturing and high levels of research in newer technologies and standards. India as a developing country does not lead from the manufacturing side in cutting edge telecom technologies and is primarily a service led industry with imported technology in wireless communications. Thirdly, Indian telecom policies are subject to policy vagaries that probably other countries do not see such changes in the scale that is seen in India with every change of political dispensation and ministers. Fourthly, Indian government has awarded 3G and BWA licenses almost simultaneously in 2010. In most other mature countries 3G was introduced in early 2000s with LTE and WIMAX commercial operations only recently being commercialized. India will have two strands of technology generations which can compete or complement each other for wireless broadband data. Again as far as mobile wireless is concerned, the existing policy is for neutrality with the decision of adopting a particular technology left to service providers. The governments in Korea and China try to push their own homegrown technologies as WiBro (Korea), SC-WCDMA (China) with EU primarily a 3GPP favorable region.

3.2 Research Methodology: Interview and Secondary research

The primary method adopted is interviews with key actors in the mobile eco system. These are semi structured in depth interviews with key managers from the service providers, equipment vendors, policy makers, industry experts and academia. The information obtained is enhanced by extensive archival and academic papers and industry news so that effective triangulation is there. The interviews were mostly conducted face to face with some respondents giving their view through email. A couple of interviews were conducted over phone. The breakup of the respondents:

Type of Respondent	Number of Respondents
Service Providers	7
Vendors	2
Policy/Regulator	2
Academia/ Consultant	2
Total	**13**

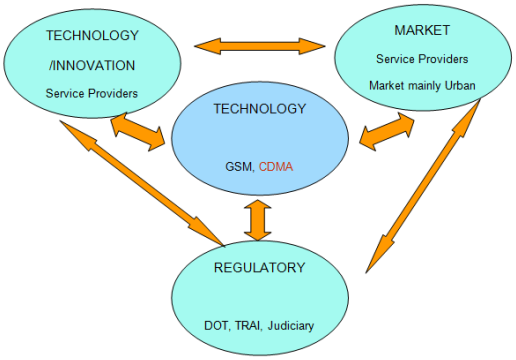
The respondents were chosen from varied background and whose interests in the mobile eco system could be in variance with each other. The number of respondents in the Service provider group is larger than the other groups as some of the interviewers had dual background having worked in the vendor community earlier. They were able to give perspective from both the vendor as well as operator standpoints.

In addition to the interviews with professionals involved in the wireless industry in India extensive archival work was conducted. Websites of Department of Telecom (DOT) and the regulator TRAI including annual reports, telecom research reports, websites of leading operators and vendors like Airtel, Reliance, Tata, Idea, Ericsson, NSN were visited for relevant information. In the international fora, websites and reports of technology groupings like CDG for 3GPP2 family of technology, standard bodies like 3GPP which is spearheading the GSM family standards going to LTE and beyond. Other international bodies like GSMA representing the operator community and GSA the association for mobile suppliers were accessed for information and data.
Trade journals like Voice and Data, Telecom Live, Telecom Asia along with newspaper and magazine reports were scanned and interviews of important stakeholders appearing in varied publications were analyzed. Archival records of these publications were traced to the early years of the mobile industry in the 90's to the present times.

SECTION 4: ROADMAP TO WIRELESS BROADBAND

The Lyytinen-King framework is applied to the three phases as mentioned in Section 1 to study the impact of the forces in the wireless industry.

4.1 *1994-2002: Initial phase of Mobile telephony with voice services*



4.1.1 Market:

The market during this period was witnessing the first mobile calls. The first mobile to mobile call was made in Kolkata in 1995 by MobileNet a joint venture between Telstra and B K. Modi Group. (Subsequently acquired by Bharti becoming Airtel) Initially only two operators were allowed per circle the operators. The mobile was seen as luxury with call rates of Rs 16 per minute and was clearly not for the masses. Competition was not stiff and the operators were focusing only on the metro and major urban areas. Along with voice,

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SMS was the other application which was in vogue. Operators were focusing only on voice with no initiative or drive towards developing other areas which might be of interest to end users. The first cellular operators in India started in the four metros:

	1st Operator	*2nd Operator*	Technology	Spectrum band	Spectrum Alloted
Delhi	Bharti	Hutchison Max	GSM	900 MHz	4.4 MHz
Mumbai	BPL	Hutchison Max	GSM	900 MHz	4.4 MHz
Kolkata	Modi Telstra	Usha Martin	GSM	900 MHz	4.4 MHz
Chennai	RPG	Skycell	GSM	900 MHz	4.4 MHz

During the end of this period, the government sector units in the form of MTNL and BSNL started providing mobile services. The market was completely driven by private operators. The government operator BSNL was the pioneer in providing services in the smaller towns and highways pan India. Private operators were ensconced primarily in the metro and urban areas

Cellular Operators Association of India (COAI) was formed by the operators as a lobby and pressure group to represent the interests of the GSM players in 1995. The 3GPP2 technology group of operators formed their own group Association of Unified Telecom Service Providers of India (AUSPI) in 1997. The fight between the two technology service provider groups started.

4.1.2 Technology:

Wireless Technology during this period was only GSM. The government had issued GSM licenses during the first allocation. The policy makers were significantly influenced by the spread of GSM in Europe. Subsequently in 1999, the government made cellular telephony technology neutral giving cognizance to other technologies in vogue (Rakesh Basant, 2002). India had no technology base in Wireless research and technology was entirely imported through equipment vendors like Motorola, Ericsson, Nokia and Alcatel. No homegrown thrust in developing and nurturing technology was evident. The end user handsets were also imported. The GSM Phase I specifications were finalized in 1990 with the first global commercial launch in 1991. GSM technology allowed data speeds of 9.6 kbps and was achieved through circuit switched data. Packet services in GSM had not seen the light of day. India as such was a technology follower during this period.
In terms of radio waves allotted for commercial mobile services in 1995, 2 X 4.4 MHz in the 900 MHz band was released for auction by the government for GSM based services for the two private service providers in each Licensed Service Area (LSA). Each LSA roughly corresponds to one political state boundary with bigger sates like Uttar Pradesh bifurcated into two and the North East states clubbed into Assam and rest of North East. BSNL and MTNL as 3rd operators also got spectrum in 900 MHz in 2001 followed by auctions for the 4th operator in 1800 MHz for 4.4 MHz in 2001. For allocations beyond the initial 2 X 4.4 MHz a subscriber based formula was introduced in 2002 for allocation going to a level of 2 X 12.5 MHz per operator (R. Prasad & V. Sridhar, 2009).

Major vendors who supplied technology for Core and Radio equipment for GSM based operations during this period were all foreign suppliers.

Ericsson	Nokia	Siemens	Motorola	Lucent
Alcatel				

The Chinese equipment vendors ZTE and Huawei opened up offices in India and started supplying in the CDMA/WLL space to the operators having license for basic operations.

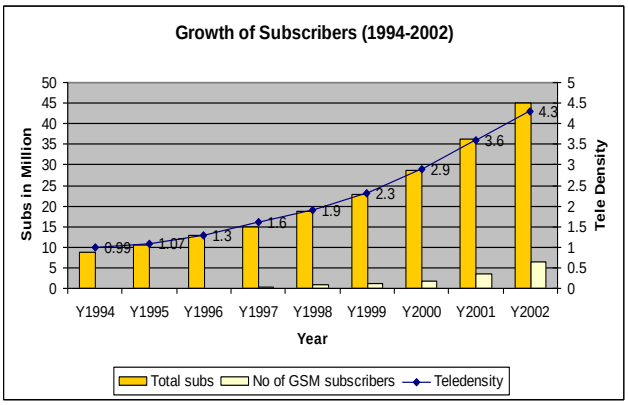

Fig: Growth of Subscribers during the period 1994-2002

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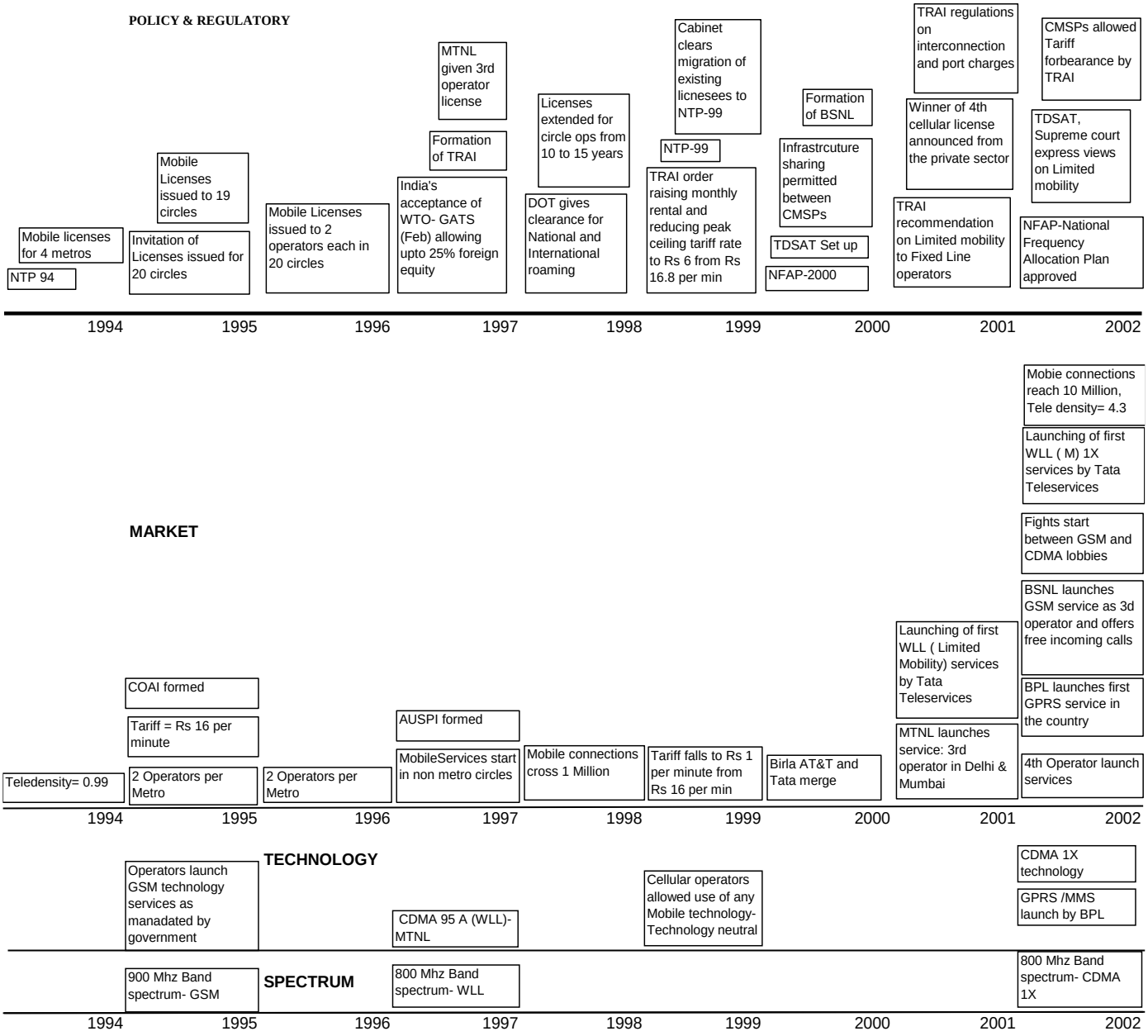

4.1.3 Policy and Regulatory:

The regulatory scenario was wholly dominated by the Department of Telecom (DOT) during the initial years. DOT was the judge and adjudicator. The NTP-94 was the first major policy initiative undertaken by the government. The government decided to allow new services like Mobile only through the private operators. Throughout the entire period DOT acted to protect its turf through policies and rules. Licenses were linked with spectrum.

The government decided to allot licenses for each of the metro areas- Delhi, Mumbai, Kolkata and Chennai for GSM services in 1994 under a under a fixed license fee regime for 10 years. This was followed by another policy decision to give licenses for the rest of the circles (sates) and 19 more telecom circles got mobile licenses in 1995.

TRAI as an independent regulator was created by the government in 1997 to delink the regulatory functions from the policy making arms of the DOT. Since its inception TRAI faced a number of hurdles from DOT who felt TRAI was intruding in its turf.

TRAI issued guidelines in 2000 for induction of 4th operator from the private sector and in 2001 the 4th cellular licenses was granted by the government after competitive bidding.
TRAI issued a consultation paper on policy issues relating to Limited mobility use by use of wireless in WLL (Wireless in Local Loop) by basic service providers and DOT subsequently issued letter of intent to private fixed line operators HFCL, Reliance, Tata Communications to offer fixed and limited mobility mobile services. COAI protested the decision and after a round of fora from TRAI, TDSAT, DOT and the Supreme Court,

The NTP-99 was issued by the government in 1999.Meantime at the end of 2002 Reliance goes ahead and launched the WLL

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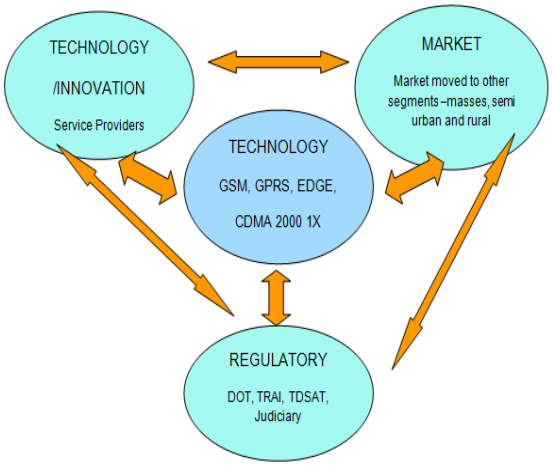
(M) services. By 1999 Tariff rebalancing exercises started with TRAI taking the lead.

4.2 *2003-2009: More competition and mass penetration with advent of data services*



4.2.1 Market:

The market saw penetration to smaller towns and cities with new operators like Aircel and Uninor targeting the lower end of the segment with attractive schemes. A number of new operators got licenses towards the later part–Aircel, Uninor, Etisalat, Datacom and Loop. One unique feature of the market is its spread to the masses. The Pre paid tariff plans became popular with the users. These schemes unlike post paid tariff schemes where the operator billed the customer at the end of a billing cycle typically a month saw huge uptake in students and the population who need to control their expenses on the basis of a nominal monthly charge. The pre paid segment of the market reached around 90% of the total subscriber base.

Airtel introduced a new concept in the Mobile telecom business by signing the first managed services deal with IBM for a 10 year comprehensive IT outsourcing followed by a mobile network outsourcing to Ericsson and Nokia in a first of its deal in 2008. (http://www.bharti.com/home/about_us/Milestones accessed on 07 august 2012). This opened a new [paradigm in the Indian Telecom scenario where outsourcing the network operations to the technology vendors and retaining the customer contact and marketing with the operators. This enabled the operators to relive themselves of the day to day maintenance and concentrate on their strengths.

Again in a first of its kind move, three private mobile operators joined hands to form an independent tower infrastructure company to cater to their passive infrastructure needs in 2006. This move exemplifies the co operative nature in Indian mobile business where stiff competition between different players is a hallmark.

Coverage for mobile services to all states and union territories increased during this period. Besides BSNL other private operators like Airtel and Reliance also established pan India coverage towards the middle of the decade.

The heated price competition in the industry started around 2003 when Reliance introduced a scheme "Monsoon Hungama" and acquired one million subscribers in 10 days. Other operators were forced to get into their own pricing mechanisms to attract customers thereby starting the cut throat pricing game in the country. BSNL launched operations countrywide in Oct 2002 with free incoming calls for some tariff plan and extended the offering in 2003 to its subscribers in the pre paid category and for all incoming calls- Fixed, cellular including all operators. This had the other operators alleging anti-competitive behavior but forcing them also to follow suit.

4.2.2 Technology:

Technology upgrades taking place globally in the wireless domain percolated to India also. 3GPP and 3GPP2 as the major branches of commercial mobile telephony introduced upgrades through various releases in the GSM and CDMA family respectively. Packet technology got introduced with the service provider BPL starting GPRS (2.5G) services in Mumbai. Other operators like Airtel and BSNL followed BPL in upgrading their systems to provide packet based wireless services along with circuit based voice services in 2003 /2004. EDGE (2.75G) providing even faster speeds than GPRS quickly followed GPRS within a year. With the advent of packet technology in the wireless domain higher speeds became possible. The spread of these services started again in the bigger cities and towns and percolated to the other areas of the country. The advantage of GPRS and EDGE was that these technology upgrades can be offered in the existing spectrum allotted to the operators with EDGE needing hardware upgrade in the Radio Base stations along with the new packet core nodes.

In the CDMA space also technology upgrades by the players who migrated to the UASL regime of licensing began happening. IEEE driven technology in the form of Wi Fi also got introduced in the country mainly to serve hotspots with MTNL and BSNL introducing services as early as 2004 in some areas. Technology during this period was again wholly imported as in the previous period. As a manufacturer of communication systems and products India has lagged behind even falling behind other Asian countries. L.F.Pau & J.Moiiwala (2007) opines that this is due to infrastructure and government regulations.

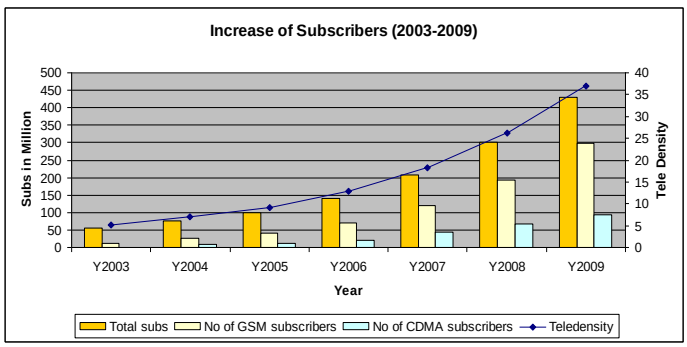


Fig: Growth of Subscribers during the period 2003-2009

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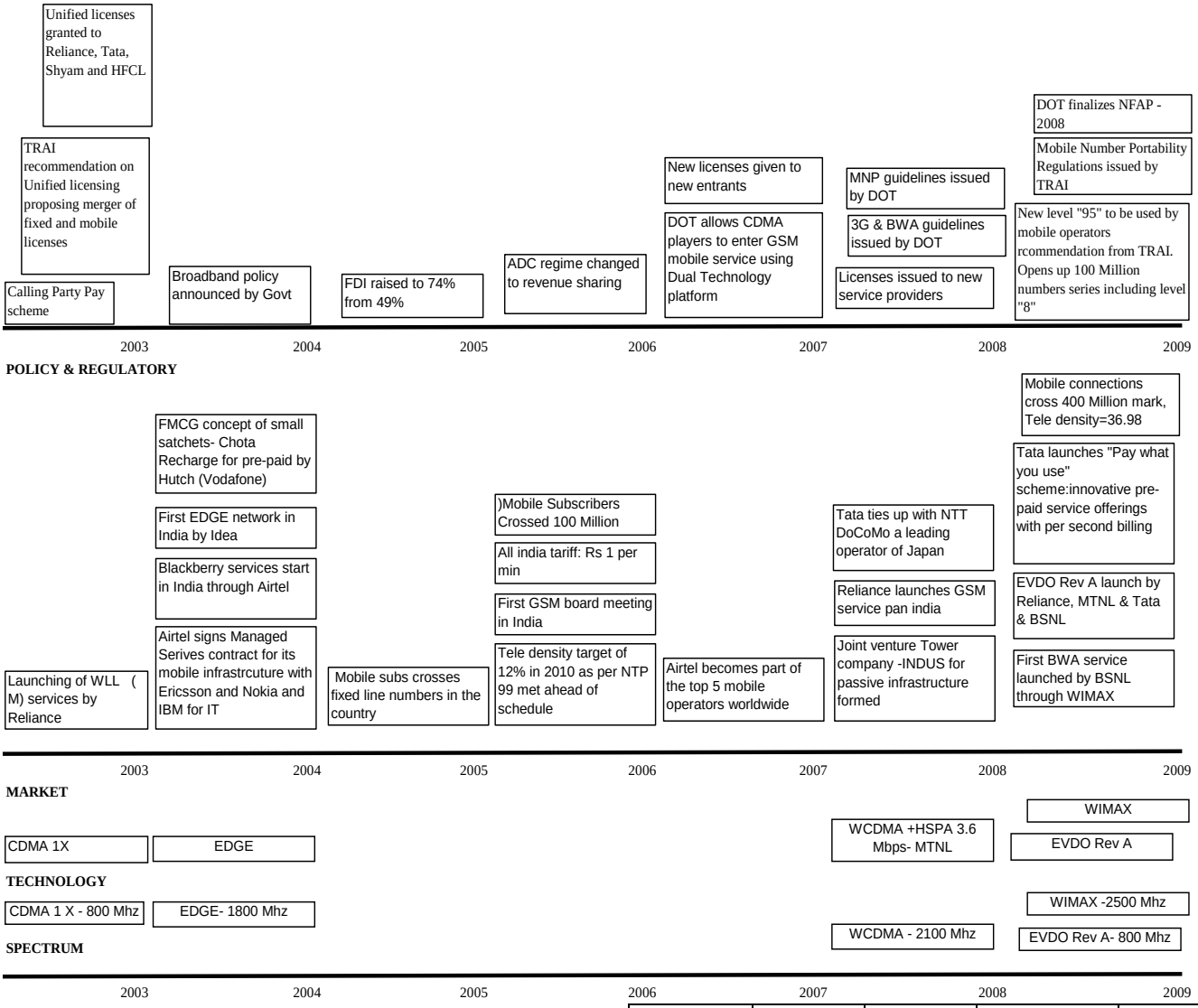


Ericsson	NSN	ALU	Motorola	Huawei
ZTE	ITI	LG	Nortel	

During the first few years of the period, spectrum crunch was being felt by incumbents (R.Prasad & V. Sridhar, 2009). The spectrum allotted to operators was way below global allotments. Having more operators also meant that the scarce spectrum need to be shared. Major vendors who supplied technology for Core and Radio equipment for GSM and CDMA during this period were similar to the previous period with primarily foreign suppliers. One Indian supplier entered the market. This lone player was ITI another government public sector unit which started supplying to the government operator BSNL for some circles. The foreign vendors also saw changes as a result of merger and acquisitions in their global operations. Lucent and Alcatel merged in 2006 while Nokia and Siemens became one entity in 2006. The Chinese vendors ZTE and Huawei also established themselves as major suppliers in both the GSM and CDMA space. With the Chinese players entering the market, the price of mobile infrastructure equipment touched new heights in lowering the cost of per line or per subscriber. The equipment infrastructure competition which was so far restricted to the European and US vendors got enlarged to include the new Asian players who offered stiff competition to the incumbents with their low prices and arranging funds for the operators to buy equipment.

4.2.3 Policy and Regulatory:

The regulatory journey continued with no clear long term strategy. Interference by the political dispensation with every change of guard and minister had its toll. The 2G scam broke out leading to the removal of the telecom minister amid allegations of widespread fraud and circumvention of policies to favor certain players. Towards the later part of this period saw the regulatory regime in a rocky situation amid allegations and counter allegations between the ruling dispensation and the opposition.

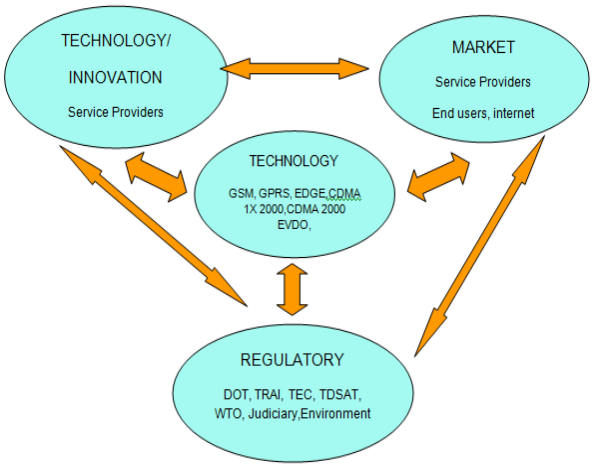
As an independent regulator TRAI also did not seem to effectively ascertain its position. Some of its actions saw its decisions being challenged in the appellate tribunal TDSAT and the courts. The judiciary was also an important player in this period with some key decisions forcing the political dispensation to take action like sacking the telecom minister. In 2003, DOT announced guidelines for Unified Access Services licenses which allowed fixed line operators to migrate to the new regime by paying a fee. Taking advantage

of this rule, Reliance, Tata Teleservices, Shyam Telecom and HFCL migrated to the new regime. UASL licenses allowed these players to provide full mobility services which they were barred so far. This was preceded by a majority TDSAT ruling that accepted that WLL (M) was legal.

The fight between the operators of the GSM technology group and the fixed line operator group offering limited mobility culminated with this policy with this round going to the CDMA players.

The government announced the Broadband policy in Oct 2004. Recognizing the need to increase the broadband penetration in the country the policy defined the minimum speed of broadband at 256 kbps and recognizing the option of terrestrial wireless in broadband penetration besides Optical, satellite, DSL and Cable technologies.

4.3 ***2009-onwards: Onset of Mobile Broadband***



5.3.1 Technology

The 3GPP family of technology family underwent upgrades with the following versions

R4 : WCDMA
R5 : HSDPA
R6 : HSUPA
R7 : HSPA +
R8: LTE

The releases are primarily based on the year. However these releases were not immediately introduced in the country. 3G (WCDMA) which saw global commercial launch in 2001 saw the first country launch in India in 2009 by BSNL seeing a time lag between global introduction and India. MTNL also launched their 3G services in the cities of Delhi and Mumbai slightly ahead of BSNL. The two public sector services providers had the first mover advantage in launching 3G services in the country as the government allotted spectrum to them in the 2100 MHz band without bidding for the same. However the two Public Sector Units (PSUs) have to pay the spectrum charges based on the L1 (lowest successful bidder) prices as determined by the auction for the private players to be held subsequent to the allocation.

The private players introduced the 3GPP family of 3G standards in 2010/2011 with all the major players Airtel, Vodafone, Reliance Infocomm, Aircel launching services. On winning the 3G spectrum, the other players started launching WCDMA progressively from 2010/2011 when Airtel launched 3G. Since India was a late entrant in the 3G technology introduction many of the players clubbed the later 3GPP release of HSPA offering higher download speeds beyond 384 kbps.

On the 3GPP2 family of standards service providers Reliance Infocomm, Tata Teleservices, BSNL and Shyam Sistema (MTS) upgraded their networks to offer CDMA EVDO with data speeds with peak speeds of 14 Mbps in EVDO Rev B.

BSNL as an operator started WIMAX services in the country in 2009 through a franchisee model as it got BWA license before the auctions for the private operators. This was the first 4G launch in the country offering speeds in the range of 7 Mbps and targeting the rural areas. Unlike the winners of BWA licenses which got spectrum in the standard 2.3 GHz band, BSNL got the spectrum in the non standard 2.5 GHz posing a dilemma for future evolution even prompting BSNL to evaluate releasing the non standard frequencies.

LTE the next evolution step for the 3GPP and 3GPP2 family of technologies has found favors with the private sector service providers with the first LTE launch in the country in Kolkata in 2012 by Airtel. LTE data service is provided as Voice over IP (VOIP) is not permitted by policy for wireless networks. Possibly this might see dilution as other operators start rolling out the LTE networks.

The government offered 5 MHz bandwidth in 2100 MHz band for 3G services with each block consisting of 2 X 5 MHz Based on the availability of spectrum, the various states of India were allotted different amounts of bandwidth. The BWA spectrum was allotted in 2.3 GHz band (unpaired) with each winner getting 20 MHz bandwidth. As regards technology the 3G and BWA spectrum was allotted in a technology neutral philosophy with the sole criteria that the technology need to be based on standards approved by ITU/TEC or any other international standards.

Allotting 2.3 MHz band (unpaired) means that if an operator wishes to deploy LTE then it would have to be the TDD version of LTE whereas many countries in Europe and US are deploying or planning to deploy in the other version of LTE namely the FDD mode. India is with China in this technology scenario which is also actively pursuing the TDD mode of LTE technology.

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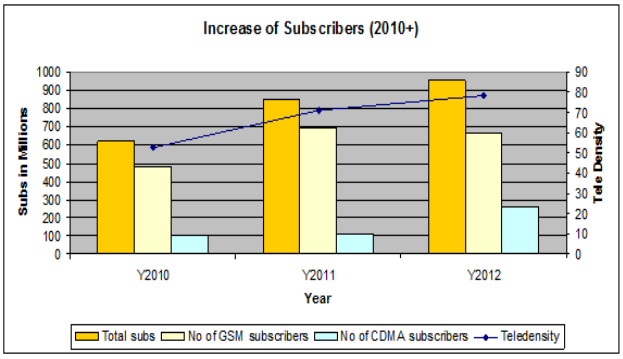
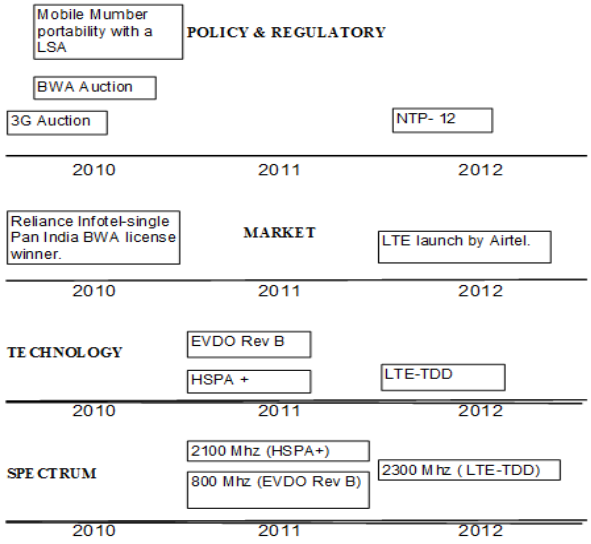




4.3.2 Market:

The voice market is still continuing to increase its subscriber base with tele density in 2009 standing at 36.98. Voice technology continues to be provided by circuit switched nodes, Although the underlying technology to provide VOIP is present with the operators having packet based 2.5G, 2.75G and 3G technology the existing policy (as of July 2012) do not allow VOIP to be offered by service providers.

3G services in the initial period did not see the uptake trajectory the service providers and vendors would have liked. The lukewarm response to 3G can be attributed to a number of factors like absence of seamless coverage, quality (QoS), pricing etc.

LTE ecosystem is in the preliminary stage during the launch by Airtel in India with only India and China as major countries that have operators committed to the standard.

The 3G and BWA spectrum auctions were held in 2010 after a lot of dithering with the BWA one following the 3G auctions almost immediately. The existing major 2G players got frequencies in 3G but on a regional level as the price per circle shot up from the starting bid amount. The bidders had to calculate and bid for the spectrum based on their overall strategy since the two auctions were held simultaneously. Banks and Financial institutions were roped in by the bidders to raise funds for the bid

Reliance Infotel secured the license for 22 circles of the country which would enable it to give the entire country BWA coverage. Existing players - Airtel got 4 and Aircel got 8 circles. Two new players in the Wireless area- besides Reliance - Tikona and Augere made their entry while US based Qualcomm got 4 licenses. Interestingly incumbent operators like Reliance Communications, Vodafone, and Idea did not make much attempt to secure the licenses and dropped out mid way. Government Public Sector Units- MTNL and BSNL had already got the frequencies secured before the private players with the condition that they would have to pay the winning price emerging out of the 3G/BWA auctions.

Hyper competition was witnessed in the market with newer entrants coming with tariff packages to lure customers and build up market share. The incumbents seeing the offerings from the newer players were forced to come up with their own offerings. The end user had a wide choice of operators and in many cases using a double SIM card phone would take connection from more than operator and use his phone based on the tariff offerings. The price war further helped penetration of the wireless market by making it affordable for the end users.

4.3.3 Policy and Regulatory:

The government announced the 3G spectrum auctions to be held in 2010. This was quickly followed by the BWA auctions. Although the purported aim of the government was increased broadband penetration, the immediate aim was to fill the state exchequer and manage the fiscal deficit as much as possible through a revenue maximization model.

As per DOT the objectives for the 3G and BWA auctions were:

- Obtain a market determined price of 3G/ BWA spectrum through a transparent process
- Ensure efficient use of spectrum and avoid hoarding
- Stimulate competition in the sector
- Promote rollout of 3G and Broadband services
- Maximize revenue proceeds from the Auctions
- Resolve congestion issues related to second generation (2G) mobile services

For the spectrum allotted for 3G and BWA, the stated policy is that any technology that conforms to the requirements can be operated by the operators. The stance taken was technology neutrality and operators were free to choose for instance WIMAX or LTE for BWA. This is in consonance with WTO guidelines for which India is a member.

Mobile Number Portability was introduced in the country in 2010 as per DOT mandate. Mobile Number Portability (MNP) allows subscribers to retain their existing mobile telephone number when they move from one operator to another irrespective of the mobile technology (GSM or CDMA) or from one cellular mobile technology (GSM to CDMA or vice versa) to another of the same operator. At the start, MNP is available to consumers within a Licensed Service Area with

plans to move to nationwide Number portability in the next phase.

With increasing subscribers TRAI recommended freeing up a new number series "95" which was used for SDCA calling from another within a circle. Based on the TRAI recommendation, this series was progressively offered to operators from 2009-2010 with a potential of providing 100 Million additional mobile subscribers.

SECTION 5: DISCUSSION

5.1 Indian efforts in Wireless Standardization:

India is primarily a net importer in wireless access technology. There have been no serious efforts to contribute in the international bodies like ITU, 3GPP etc. Although India do has representation in ITU and other bodies but India cannot be counted in the same league as other Asian counterparts like Japan (ARIB) or Korea (TTI) as an active contributor to the wireless standardization process globally. Bodies like Telecommunication Engineering Centre (TEC) an arm of the Department of Telecommunications, Indian Institute of Technology (IIT) and others are there but global industry contribution is negligible to say the least. IIT Chennai's efforts to develop CORDECT as an indigenous wireless technology for WLL never got the steam it needed in the country for deployment.

CeWIT is a forum on Public-Private partnership project between the Ministry of Communications and IT and Broadband Wireless Consortium of India (BWCI) having different stakeholders like Ericsson, Alcatel Lucent, Airtel, and Sasken with others. It is an autonomous research institute to work on advanced research in wireless technologies to meet the needs of the Indian market.

The Global ICT Standardization Forum for India (GISFI) is a body started in 2009 with a view to create to strengthen the role of India in the world standardization process by mapping the achievements in ICT in India to the global standardization trends. Another recent attempt is a Development Organization of Standards for Telecommunications in India (DOSTI). It is a SDO that aims at developing and promoting India-specific requirements, standardizing solutions for meeting these requirements and contributing these to international standards and contributing to global standardization in the field of telecommunications. DOSTI is set up in Public-Private Partnership (PPP) model similar to CeWIT with participation from the Government and industry including academia. It remains to be seen how India moves ahead with these initiatives in its efforts to join other advanced countries in Europe, US and Asia in the wireless standardization process.

Many global telecom vendors like Samsung, Ericsson and Huawei have R&D arms in India and also outsource part of their new product and technology design to Indian IT companies. But the final product does not get the India tag. With active support from the industry, government and academic institutions this could change in times ahead since India with its unique requirements can contribute a lot and also help other countries in the learning curve.

5.2 Vendors in Wireless Infrastructure and Services*:*

Wireless infrastructure vendors during the starting years of the Indian mobile were mainly European and US based. European vendors supplying telecom gear were Ericsson, Nokia, Siemens, and Alcatel while US vendor was Motorola. These companies supplied the first operators in India with GSM equipment Switches and Radio access equipment. These vendors supplied equipment adhering to the GSM family which the government mandated as the starting technology for mobile in India .With the introduction of CDMA technology in early 2000s saw vendors like Ericsson, Alcatel and Chinese vendors in the form of Huawei and ZTE. Huawei setup its R&D centre in India in 1999 and started supplying telecom gear from 2001-2002 onwards. ZTE started almost the same time as Huawei with supplies to BSNL for CDMA and has since then have supplied GSM, WCDMA and LTE equipment to other Indian service providers. Indian public sector unit ITI who was already in the fixed line switching space entered the fray with manufacturing BTS and BSCs for GSM technology. However, it was unable to make its presence outside BSNL.

With advent of packet core and LTE, the traditional vendor space held by the European and Chinese vendors saw new entrants. Cisco which made its name in the IT space with its routing and switching portfolio made its entry in the core mobile infrastructure space in the packet core equipment segment. The traditional radio access segment also is seeing new competition with Samsung joining the fray with its LTE offerings.

Applications space has myriad competition. International names are jostling for space with smaller and nimble Indian players. Besides service providers themselves also are in the fray for launching applications. There are multiple layers as far as applications and content goes. One scenario is existing service providers with their own applications. The second is with service providers tying up with application and content providers and lastly independent application providers. The bandwidth and access to the airwaves is all that is required for the application to run. This space does not call for massive investment as in radio and core equipment and with 3G, EVDO and LTE on the rollout in India could see increasingly more players coming in.

In the end user equipment front, handsets for voice calls in GSM and CDMA were sourced from outside the country. The lucrative Indian market beckoned Indian players in the fray and a wide range of Indian manufacturers are offering 2G and 3G handsets in the market with competitive pricing.

5.3 Spectrum Availability & Efficiency

Spectrum in India for mobile operators has been a challenge. Every operator is experiencing a spectrum crunch because of the increasing number of subscribers. The figure below for Delhi area and Orissa (before the cancellation of some licenses by the courts) as an example of a non metro state shows that the total spectrum in the range of around 140 MHz is shared

between 11 to 14 operators with an average of around 10 MHz per operator including all wireless technologies in the circle. This is way below the global standard of around 40 MHz per operator in western economies US and UK and 60-70 MHz in Germany and Sweden (J.Markendahl and B.G.Mölleryd, 2012). With the meager spectrum, operators have to squeeze in as much as possible within the allotted band and to cater to capacity; coverage and Quality of service have to put more Base Transceiver Stations (BTS) sites increasing the Capital and Operating expenditures. The boundary condition that they have to fulfill is to meet the regulatory guideline of adhering to the maximum power emission from a site to cater to the EMF radiation norms.

Sl No	Operator	800 MHz	900 MHz	1800 MHz	2100 MHz	2300 MHz	Total
1	Airtel		8	2	5		15
2	MTNL	2.5	6.2	6.2		20	34.9
3	Vodafone		8	2	5		15
4	Aircel			4.4			4.4
5	Reliance	5		4.4	5		14.4
6	Tata	5					5
7	Idea			8			8
8	Swan			4.4			4.4
9	Shyam	2.5					2.5
10	RIL					20	20
11	Qualcomm					20	20
	TOTAL	**15**	**22.2**	**31.4**	**15**	**60**	**143.6**
	Average spectrum per Band	*3.8*	*7.4*	*4.5*	*5*	*20*	*13.1*

Figure: Delhi spectrum allocation

Sl No	Operator	800 MHz	900 MHz	1800 MHz	2100 MHz	2300 MHz	Total
1	STEL			4.4	5		9.4
2	Reliance				5		5
3	Aircel			4.4	5	20	29.4
4	RIL					20	20
5	Vodafone			4.4			4.4
6	Reliance	2.5	6.2	0			8.7
7	BSNL	2.5	6.2	3.8		20	32.5
8	Airtel		6.2	1.8			8
9	Datacom			4.4			4.4
10	Idea			4.4			4.4
11	Unitech			4.4			4.4
12	Loop			4.4			4.4
13	TTSL	2.5		4.4			6.9
14	Shyam	2.5					2.5
	TOTAL	**10**	**18.6**	**40.8**	**15**	**60**	**144.4**
	Average spectrumper Band	*2.5*	*6.2*	*3.7*	*5*	*20*	*10.3*

Figure: Orissa Circle spectrum allocation

The technology available for maximizing the efficiency in one generation gets limited over time to cater to newer requirements and this leads to development and deployment of newer generations of technologies or an altogether new technology. The same goes for wireless technologies also.

The requirement of spectrum with increasing usage of data applications will push the government for releasing newer spectrum bands besides the current ones" 800 MHz, 900 MHz, 1800 MHz, 2100 MHz and 2300 MHz This could come in 700 MHz, etc

Various scenarios for spectrum management can emerge both at the policy level as well as the operator end. The government needs to work on a host of options on the spectrum management front.

1. Freeing up more spectrum for commercial usage from other agencies like the Defense and Broadcasting which are holding the frequencies
2. Spectrum re farming: Push from the authorities to the incumbent operators to go in for more efficient wireless technologies
3. Allow spectrum trading among service providers
4. Make the spectrum free and charge for licenses for providing services

On the service provider end, they too can contribute towards the efficient use of spectrum

1. Upgrade existing technological systems to newer versions. An instance can be EDGE evolution in GSM systems which can offer increase data speeds beyond 1 Mbps. An operator can use the GSM spectrum to provide data services and use the other spectrum for instance to pump in more voice users in a particular coverage area
2. Leverage on newer features and functionalities on advancements of existing technology. As in GSM one timeslot on average caters to one user. Implementing half rate with enhanced Codecs (Coding-Decoding) like Adaptive Multi Rate (AMR) can reduce noise and also help to cater to two users in one timeslot. The next step in this direction known as VAMOS which enables four users in one GSM timeslot. With increasing time, end user device like handsets also become available in the market to cater for these technological advancements. These improvements like VAMOS can help an operator to serve four voice customers in one GSM timeslot thereby increasing the capacity of a BTS to service more subscribers without adding a new frequency or site
3. Adopt techniques from different vendors like Frequency Hopping, Interference minimization from other signals and better synchronization of BTSs
4. Better Radio frequency tuning and site optimization to prevent call dropping and better signals
5. Introducing the Cloud in the radio access segment. This will free up the radio transmitting part from the baseband processing part leading to efficiencies in the radio access area
6. Mix and match of technologies to cater to niche requirements and specific segments - Wi-Fi in unlicensed band for hotspots and 3G or LTE on the outside for outdoor coverage

5.4 Increasing Co- opetition

The term "co-opetition" defines the modern corporate strategy that combines competition and cooperation. Co-opetition would mean "cooperation for competition" which translates to the view that two or more competing organizations cooperate to create a bigger business pie and simultaneously compete for bigger pieces (Nalebuff and Brandeburger, 1996). The terminology "co-opetition" was initiated by Ray Noorda who founded the networking company Novell. (Barbara et al, 2011). Indian wireless industry which is fiercely competitive within various segments of the industry – Operators, vendors, application developers and VAS fields offers co-opetition philosophy as a strategy.

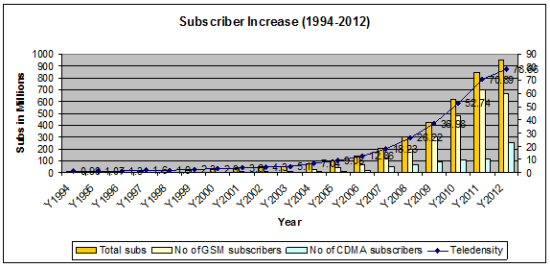
The trio of 3GPP family of service providers- Airtel, Vodafone and Idea fight each other in terms of offerings to end customers but joined together to form a joint company for tower and other site related infrastructure known as Indus. Indus has helped all the three companies to reduce their expenditures in building independent BTS sites to give RF coverage to the same area. With a single tower and erecting their independent antennas and BTS, these companies managed to reduce their costs substantially. As of 2012, Indus has some 112,000 towers (accessed on Sept 14, 2012, www.industowers.com) across 16 circles of the country which besides serving the needs of its 3 owners also cater to other operators. The same tower can support any technology GSM, 3G and LTE that each independent operator may wish to serve in an area.

The above triad of operators took another initiative in co-opetition when 3G was launched in the country in 2011. Because of the high spectrum charges, they did not bid for all the states and went in for the states where they felt 3G coverage would strengthen their offerings. An agreement called ICR between them saw light of the day. The agreement allowed each vendor to offer 3G subscription in areas where they do not have 3G spectrum. In going for this strategy they ensured they have 3G subscribers in states they do not have the spectrum. The question of how the ICR concept takes shape in times ahead with the policy and regulation needs to be seen but ICR saw a segment of operators collaborating for increasing their subscriber base and also fighting for 3G subscribers in the same area.

With the pressure of low tariff and increasing data usage, operators would need to find ways of reducing cost, retaining brand loyalty and increasing mind share with consumers. Co-opetition allows players to achieve these objectives and the market would see prevalence of the same with increased collaboration amongst them. This does not rule out competition in days ahead. With passive sharing of towers currently and with sharing of active elements of the network infrastructure like Radio access, Cloud RAN etc, it only needs policy framework /regulatory approval. The technology for active sharing exists and is increasingly finding usage in other markets of the globe.

5.5 Markets:

Since the first mobile call in 1995 in India and 17 years down the line, voice is still going strong. Voice revenues for most operators comprise the bulk of their wireless revenues as much as 85% with only VAS and non voice segments in the range of 15%. (The hindubusinessline.com, 14 sept 2012) Data is slowly making its presence felt and with 3G, 4G with Wi-Fi getting deployed data is expected to grow in coming days with the basic pipes in place. This will also enable VAS offerings beyond SMS and Ring back tones.



The markets

a) Newer players:

The wireless operators could see increased competition not only from their traditional ones but also from other entities that see opportunity in the converged space of wireless, multimedia, IT, broadcasting and increased communication needs for man to man, man to machine and machine to machine. Social websites and networking with increased proliferation of affordable Smart phones, dongles, tablets and PCs have the potential to muddy the waters in the times ahead. Increased penetration of these devices would help in the rise of data traffic but at the same becomes lucrative for players from the internet and IT space to make inroads into the space. Instances of Google, Apple, and Amazon are there in other markets who are jostling for space in the market. The program Skype enables users to make Voice and video calls free of charge as long as users have compatible devices. VOIP calls which are restricted from wireless through Indian policy currently can easily be offered through wireless as it needs only a bit pipe to carry the traffic. This space needs more study. The reverse flow of operators to the space of internet space also is rearing its head. Idea and Airtel for instance have application stores that offer subscribers access to numerous applications which are also offered by Google (Android) or Apple (IOS).

b) Newer Functionalities and Applications.

Regional level applications with local vernacular with ease of usage are needed. Currently applications are more addressed towards the urban segment. Local content in the shape of district or town or village level information would help rather than a broad entity like a state level content. With increased data coverage and awareness and to drive the broadband applications on a wide range to cater to the mass scale innovative applications would be the need. Common issues faced by the citizenry in their interaction with public and government agencies like health, municipality, education, banking and the like would increase the traction for usage. Entertainment and the sports especially the game of cricket is hugely popular with all segments of users and movie clips, TV, songs, live cricket matches and similar available on the go.

5.6 Innovation at Work

The Indian consumer is price sensitive and the India growth story in telecom penetration showing staggering penetration has tariff plans playing a major role. Affordable tariffs that could be sustained by the common man on the street and

teenagers helped fuel the growth of mobile subscription. Tariffs have been continuously declining over the years starting after the TTO issued by TRAI in 1999. Various options are now available for a consumer- Post Paid, pre-paid, friends and family with a discernible user choosing a particular tariff plan based on his usage pattern. However pre paid scheme is the one which has and which continues to hold sway with more than 90% of consumers opting for the scheme. With pre-paid, users have more control of their usage and consumption. A teenager can charge her mobile with so much money that her pocket money can afford. The neighborhood electrician can now take a mobile connection for incoming calls from his customers desirous of availing his professional services while putting a small amount of money in his account for important outgoing calls. The benefit of the pre paid scheme extended to the service provider too. The operator now has money upfront from a consumer without worrying about bad debt from his consumers. In India where sheer poverty can make farmers commit suicide or go on perennial debt to the money lender here is one scheme that makes the service provider as well as the end user in control of the finances to an extent.

Instances of introducing new and innovative pricing plans are seen across operators.

In 2006, BSNL introduced "India One" Tariff plan which enabled subscribers to call anyone in India at Rs. 1/min on payment of a fixed monthly rental of Rs 299. Similar plans followed by other service providers. Reliance launches "One Nation One Rupee" plan. Tariff schemes with lifetime validity: The idea behind these schemes is that users can get the benefit of incoming calls without incurring fixed recurring costs.

In 2009 Tata introduced per second billing for pre paid subscribers to a market which was unused to such a novelty. The end user has to charge his card which after deduction of administrative charges was then charged by the minute in most cases. This scheme attracted wide attention among end users and forced other operators to follow suit and offer similar tariff plans.

5.7 Technology Enhancement:

The onset of commercial wireless deployment in the country starting from 1995 saw the European standard GSM introduced in the country. This as mentioned was mandated by the license condition set by the Department of Telecommunications. The first lot of operators by default took up this technology and rolled out the networks.

Policy change was affected in line with National Telecom Policy (NTP-99) wherein technology neutrality was taken as the new mantra by the government. The basic license holders including MTNL started WLL with CDMA as the technology in the 800 MHz frequency band as this band had been marked for WLL systems. MTNL started the basic services with the CDMA IS 95A standard in 1997. With government affecting a policy change by allowing basic players to migrate to a regime where they are allowed full mobility from limited mobility as in WLL, the basic players used the 800 MHz spectrum band to give full blown CDMA offerings with CDMA 1X coming in the year 2002. For quite some time this generation of CDMA was radiated by the Unified License holders till 2009 when 1X got upgraded to EVDO Rev A. This gave system capability to the operators up to 3.1 Mbps. This was followed soon by a new upgrade to EVDO Rev B by most of the CDMA operators. This technology upgrades to EVDO Rev A and Rev B allowed the operators to compete with the GSM family of standards in terms of data speed.

The GSM standard which was adopted by the first operators to be issued mobility licenses was also adopted by the 3rd and 4th operators including the new licensees in the later part of the first decade of 2000. The only exception with the later group is Shyam Sistema (MTS) which took up the CDMA family of standards. The growth phase of the mobile was apparent from the start as the country was hugely lacking in telecom penetration. The focus of the operators was coverage and capacity for voice and the GSM standard served the purpose fully. Since the major operators took up GSM it allowed roaming nationally as well as internationally as many countries in Europe and Asia also took up the GSM standards with exceptions like South Korea who vigorously adopted CDMA family by design and choice. Although coverage was continuing in the 2000s, the operators did see an avenue to enhance their offerings by offering an upgrade to the GSM systems by bringing in packet based switching capability. Upgrading to GPRS enabled the operators to offer higher data throughput in the range of 50 kbps compared to about 9.6 kbps in only GSM. GPRS also came to be known as 2.5 G. Upgrade to GPRS was possible with the same frequency band held by the operators in the 900 and 1800 MHz The next step for the GSM or 3GPP family GPRS was EDGE or Enhanced GPRS allowing throughputs of about 150 kbps. The beauty of EDGE was that as similar to GPRS it was still possible to offer the enhanced service in the same frequency band. However to offer EDGE some part of the frequency had to be allotted for EDGE service from voice. With limited spectrum this presented some tough choices for the operators. Enabling EDGE meant that they had to sacrifice some bandwidth of the frequency band for data in lieu of voice. The conundrum was how much to allot for voice and how much for data in the available bandwidth. Having data capability allowed browsing and surfing the web possible and video/TV achievable with these technologies although buffering and latency played their part.

MTNL and BSNL launched the first 3G services in the country in the 3GPP family. The frequency bands in the 2100 MHz was allotted to them as part of the government policy to earmark bands in 3G and BWA for these entities. Being late by several years in the 3G technology adoption than countries like Germany, UK etc can also have its advantages. The Indian operators leapfrogged to HSPA while launching 3G in 2008.The private operators Airtel, Vodafone, Idea, Aircel even went one step further by upgrading to HSPA+ since their launch in 2011. Both the 3GPP and 3GPP2 families had system upgrades and launches in 2011 in HSPA+ (21 Mbps) and EVDO Rev B (14 Mbps).

5.8 Technology Battles -1: CDMA versus GSM

The GSM family has more service providers offering it as a technology than CDMA. For CDMA the players are Reliance, Tata, MTS, MTNL and BSNL. The only single technology CDMA player is MTS while the other three are dual wireless technology players. The end user has a much wider choice with GSM operators. For the price savvy consumer where even a rural person has more than a single SIM to take advantage of pricing schemes this proves a hindrance. For one if he decides to take a GSM connection, he has to have another handset or take a dual technology handset which is not so much prevalent. GSM has low cost handsets available in the market. A GSM user simply takes a new SIM card; insert it in his existing handset and goes with his communication needs.

Again if a user wants to change his service provider because of network coverage, billing or other issues he has limited choice when he opts for CDMA technology operator. When MNP was launched in India in 2010, one of the largest migrations that happened in the initial months was a shift from CDMA technology to GSM technology operators.

In the early years of CDMA in India, another issue faced by a user was roaming. CDMA is more prevalent in the US, Korea etc but if a business user goes to Europe or other parts of Asia like the Middle East, he has to carry a GSM handset. The geographical coverage of GSM is much more than CDMA. The popularity can be gauged from the number of subscribers to GSM compared to CDMA in the world. Of late, operators are providing an option for GSM roaming with a CDMA handset operating in India. It made more sense to stick with a phone that works predominantly in the home country. The widespread use of GSM also lured the handset manufacturers to cater to a more numerical consumer base

CDMA offers inherently superior radio characteristics compared to GSM. The distinction between GSM and CDMA will narrow down as we go forward to LTE as both technologies evolve to the standard, the superiority of CDMA in the air interface is also seen in the 3G version – WCDMA which uses spread spectrum technology like CDMA which can be referred as an enhanced version of CDMA.

US firm Qualcomm being the developer of CDMA technology has a hold in the patents. It gets a license loyalty for each CDMA handset or radio Base station sold in the market. In a way GSM is an open standard while CDMA is a patented technology. Not that it means that firms like Ericsson, NSN etc does not hold patents in the GSM but since more firms are engaged in the GSM technology no single firm has monopoly on the essential patents to deploy or run the GSM technology. The spat between the largest Indian CDMA operator and Qualcomm started around 2005/2006 over the royalty paid for the CDMA handsets with Reliance even roping in the telecom minister to argue the case for lower royalty. Qualcomm went public that royalties paid in India are lower than other countries like US and Korea and offered sops like joint marketing, advertising and volume discounts while Reliance insisting on lower royalty per unit. The market rate for royalty was as high as 7% as indicated in 2006. Tata Indicom as the other major player in the CDMA technology in India also built the pressure on Qualcomm. It is interesting to note that on a global level handset manufacturers Nokia and Samsung too had brushes with Qualcomm over royalty with Qualcomm emerging victorious in the legal tangles inducing Nokia at one stage to pull out of the CDMA handset business.

After the government announced the policy of allowing dual technology in the mobile area, the market font runners of the CDMA family Reliance and Tata both opted to launch GSM. This was prompted by the desire to avail the positive network effects the GSM family brought in India. As per TRAI records both have acquired a number of subscribers to the GSM family of operation with a growth rate better than their CDMA subscriber growth rate. Tata, Reliance and MTS seem to have defined their strategy for their CDMA networks. While MTS is pushing ahead and branding itself as a serious mobile data player, Tata is positioning its CDMA network for data and for voice trying to lay stress on its GSM network while Reliance is focusing on winning the low value voice user for its CDMA network while providing data services also. The road ahead beyond EVDO Rev B will depend on how Qualcomm comes up with their upgrade path. Although the next evolution path for CDMA is LTE, however considering the lesser spectrum for current CDMA players, the challenge will come after 2-3 years when EVDO Rev B will live its utility.

The government spectrum policy also seems in a way to favor the GSM technology operators. A start up frequency of 4.4 MHz is meant for GSM players while 1.25 X 2 MHz for CDMA players. An operator having more frequencies in India means he is more valued. With two carriers of 1.25 MHz means that a CDMA operator cannot fully utilize the technological capabilities of EVDO Rev B of 14 Mbps and has to be content with a peak speed of about 4 Mbps only.

When Reliance entered with a bang on the mobile industry in India in the early 2000 with CDMA technology, it targeted the masses for the services with its marketing and advertising blitzkrieg. CDMA in that sense was relegated as a technology meant for the lower end of the segment in the Indian context. Only with network upgrades to EVDO data capability was the marketing paradigm shifted by companies like MTS as a technology with more data enhanced data capability than GSM.

5.9 Technology Battles -2: WIMAX versus LTE

WIMAX technology made its debut with operators like BSNL, Airtel and Aircel deploying it for serving Enterprise and Small and Medium Enterprises (SMEs) from 2007. The fixed variant of WIMAX 802.16d was deployed by these firms as last mile connectivity. Spectrum in 3.3 GHz band was adopted for these services as per regulations with 12 MHz and 14 MHz bandwidth allocations.

The real battle in WIMAX versus others started with the government announcing the intent to go for BWA spectrum allocations. The lobby groups from the opposing sides started to position the advantages with the competitor technology disadvantages in industry publications, forums, and operators and to other interested players. Along with industry groupings

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like WIMAX forum, GSMA and others pitching in, the vendors manufacturing the equipment for the technologies also came in trying to do consultative selling to the potential buyers. For some vendors it was clear like Ericsson who does not have WIMAX in its portfolio. For others like Huawei which support WIMAX and the competing technologies like CDMA EVDO and LTE, it had to play a more balancing act in playing one technology over the other. At the time of going in for the BWA auctions in 2010 it was still not clear which way the battle would be won. Post victory in the BWA auctions, RIL and others started giving statements that they were evaluating all technologies. For smaller players like Augere, the strategy was simpler. Whatever big brother RIL would choose for its pan India BWA it can simply follow in its footsteps. This will help in making the ecosystem part easier for the BWA technology deployment.

The advantage of WIMAX is that it has been present for some years. LTE is a relatively newer technology whose specifications had been frozen quite recently. LTE being in the evolution path of the 3GPP and 3GPP2 families the existing operators like Airtel and Aircel would seem to prefer it as many of the existing infrastructures for GSM and HSPA could be common. The major worry was the availability of the ecosystem in terms of end user devices. China's intent to go for LTE in the TDD mode which matched the frequency spectrum for BWA in India also seems to assure operators. With two major countries with huge populations the TDD version of LTE, ecosystems for the technology in terms of end user devices like dongles etc could possibly be made available and at good price points for the end user.

5.10 Multi Technology Multi-Vendor deployments

While the operators were scaling up their networks in terms of voice and data capability by different technology upgrades they also introduced newer technologies/upgrades in parallel to existing technologies. For instance, HSPA+ was rolling out and at the same time to meet coverage and capacity requirements they were enhancing the capability of the GSM systems. Again massive investments made in a technology like GSM which offers utility value cannot be scrapped once a new technology comes in. Meantime, the radio access systems and other system upgrades in the transport and switching systems were also taking place. Since the access systems need to be connected to the transport systems to be connected to the control layer comprising of switching systems etc. Newer VAS systems were also getting integrated by the operators.

From the start in the 1990's in one particular geographical area the infrastructure vendors like Ericsson, Nokia, Lucent, Siemens and Alcatel had areas curved out exclusively in radio access and core and in some cases both were supplied by the same vendor in that area. With increasing scale of deployments and getting better prices, operators started taking equipment from different vendors and integrating in the network. This was possible as the interface between access and core systems were open meaning that proprietary protocols between these two systems were not there. An increasing reason for the operators to deploy systems from different vendors was the price points offered by the vendors. This led to a multi technology multi vendor scenario in wireless systems deployed with most operators. With 3G and BWA deployments picking up in times ahead, multi technology multi vendor scenarios does seem to stay in the wireless landscape of the country.

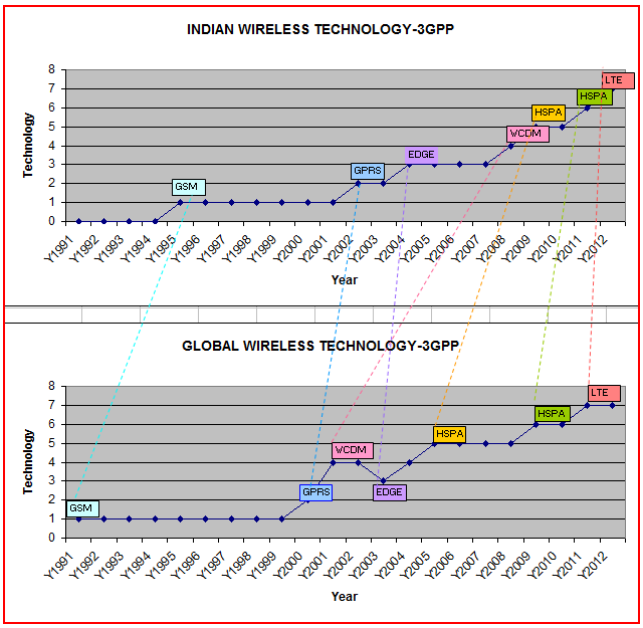

Fig: 3GPP (GSM) Family of Technology progress: India Vs Global

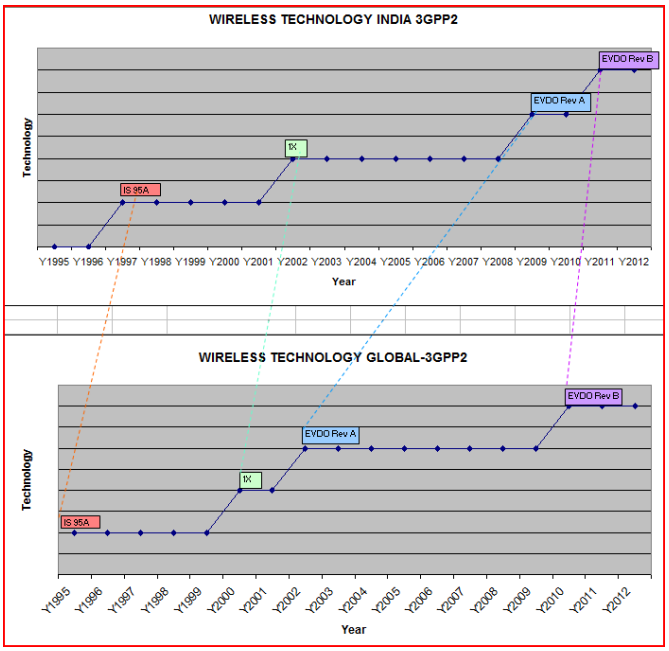

Fig: 3GPP2 (CDMA) Family of Technology progress" India vs. Global

5.11.1 1st generation of Cellular players: the 1st and 2nd Licensees: 1995/1996

The first and second license winners in the metros and rest of the circles chose GSM as the technology to be deployed in their networks not because they did not want to evaluate other

available wireless technologies but because the mandate given by the government to them was to deploy GSM. The government was influenced by the pan European decision of going for a single standard. Adoption of digital standard Global System of Mobile Communications-GSM was taken as a policy and since mobile services was to be provided by the private sector players, the winning operators had the decision of choosing the wireless technology cut out for them.

5.11.2 3rd and 4th Licensee Cellular Players: 2001/2003

Once the government decided to deploy mobile services by coming in as 3rd operator, it decided to adopt GSM again as the technology choice. The consideration for the government was to have deployment in the 900 MHz frequency band and to avail the benefits of network effects to the already installed wireless database by the first and second operators. If the choice would have been CDMA a new wireless eco-system need to be built in the country. Both MTNL/ BSNL called for tenders to supply equipment and infrastructure explicitly for GSM from all technology vendors like Ericsson, Lucent and Motorola. In fact the tender issued by BSNL clearly stated GSM technology to be supplied.

The CMTS guideline by DOT for mobile licensees post NTP-99 for technology choice specifies the following:

- *Meet the relevant International Telecommunication Union (ITU)/ Telecommunication Engineering Centre (TEC) standards. The technology should have a customer base of 1,00,000 or above for above one year anywhere in the world*
- *Any digital technology*
- *The frequencies as per national frequency Plan. Appropriate frequency spots in GSM band of 890-915 MHz paired with 935-960 MHz will be assigned to operators selected for vacant slots and 1710-1785 MHz paired with 1805-1880 MHz will be assigned to fourth cellular operator. A maximum of up to 4.4 MHz + 4.4 MHz will be permitted. This can go up to f 6.2 MHz +6.2 MHz*

The winners of the 4th licenses issued by the government were all incumbent operators- Airtel, Escotel, Hutch, Reliance (Reliable Internet Services), Idea (BATATA). The condition stipulated by DOT was that existing licensees could not bid for their own service areas. This enabled the above five service providers to bid for other circles in which they desired presence. Notwithstanding the fact that they would get 1800 MHz band.

As existing service providers all of the above except Reliance had deployed GSM as their technology choice in the circles they operate. Although the government had made the choice of technology neutral, for these operators it did not made sense to go for any other technology at this point of time. The winning strategy was to increase their presence in other areas where they do not operate in the country. The frequency band allotted for the 4th winner was 1800 MHz this presented a technical and commercial challenge is that because of the higher frequency the area of coverage was lower than that of the 900 MHz which meant that they would have to put more BTS sites. India now added 1800 MHz band to the previous band of 900 MHz and the GSM ecosystem got enlarged in terms of equipment and terminals. This did not present issues in the end user handsets since many global operators have deployment in the 1800 MHz band and end user terminals are available that work in both 900 MHz and 1800 MHz bands.

5.11.3 Basic License providers' choice of technology

As part of the telecom liberalization, India also allowed one private operator to compete with the incumbent DOT to provide basic services. MTNL started giving limited wireless access to its subscribers by using CDMA IS95A version in 1997. The other basic operators also lobbied with the government for using limited mobility by using CDMA. After going through several rounds of discussions, representations, litigations and recommendations with some acrimonious fights with the GSM lobby the government finally gave way and allowed basic service providers to provide mobility services. Reliance, Tata and HFCL introduced CDMA 2000 1X digitals services. With this introduction, an alternative Digital wireless standard got introduced in the country. The CDMA players all started radiating in 800 MHz band.

The UASL guidelines from DoT specify:

- *Technology should be based on standards issued by ITU/TEC or any other International Standards Organization/ bodies/Industry such as 3GPP/3GPP-2/ETSI/IETF/ANSI/EIA/TIA/IS. The technology should have a customer base of 1,00,000 or above for above one year anywhere in the world*
- *Initially a cumulative maximum of up to 4.4 MHz + 4.4 MHz shall be allocated in the case of TDMA based systems @ 200 KHz per carrier or 30 KHz per carrier or a maximum of 2.5 MHz + 2.5 MHz shall be allocated in the case of CDMA based systems @ 1.25 MHz per carrier, on case by case basis subject to availability. A maximum of 5 + 5 MHz in respect of CDMA system or 6.2 + 6.2 MHz in respect of TDMA based system shall be allocated to any new Unified Access Services Licensee. The spectrum shall be allocated in 824-844 MHz paired with 869 – 889 MHz, 890 – 915 MHz paired with 935 – 960 MHz, 1710 – 1785 MHz paired with 1805 – 1880 MHz*
- *For dedicated carriers for micro-cellular architecture based system, it will be assigned in 1880 – 1900 MHz band with the spectrum not more than 3.75 + 3.75 MHz in respect of CDMA system or 4.4 + 4.4 MHz in respect of TDMA system.*

5.11.4 The Public Sector Units -MTNL and BSNL:

Being the 3rd licensee operators the government public sector units started late into the game in 2001. They both launched GSM as their choice of technology. Being incumbent fixed line providers they also went in for CDMA technology for the basic services. The networks are CDMA EVDO enabled and though the coverage is spread throughout, the service providers are unable to leverage the strength of the technology while going all out for the GSM based technology. BSNL also has the IEEE mobile WIMAX services deployed. This is mainly aimed at the rural areas with claims of coverage up to

15 Kilometers from the BTS site. WIMAX as part of the BWA licenses is offered primarily through the franchisee model and like the 3G WCDMA/HSPA launched by MTNL and BSNL in 2009, BSNL is the first operator to get off the block for BWA after getting preferential allocation of spectrum along with MTNL. Spectrum continues to bog Indian operators and while private operators have got bandwidth in the standard 2300 MHz band for BWA. The band allotted is in conformity with the standard LTE bands and hence BWA licensees can launch LTE-TDD in the allotted bands. The irony is that even after getting preferential treatment by way of getting BWA spectrum, BSNL cannot launch LTE to be in synch with the private operators and enjoy the benefits of network effects as the spectrum allotted to BSNL lies in the non standard 2.5-2.69 GHz band. The eco system for LTE in the BSNL allotted band is yet to develop and the challenge is whether to go ahead with WIMAX as the lone operator across the country or avail the option of returning the spectrum and have another go at BWA licenses when future spectrum in 700 MHz and other bands open up. Being first off the block does present challenges sometimes and BSNL in the case of BWA could not avail the first mover advantage.

Having CDMA EVDO Rev A coverage in areas much more than the patchy WCDMA/HSPA coverage, BSNL can utilize CDMA technology to reach out to more data users at 800 MHz and complement the other technology for more broadband data penetration.

5.11.5 The Big 3 GSM players: Airtel, Vodafone, Idea

The trio of Airtel, Vodafone and Idea has good presence across the country and they have gone in for the 3GPP GSM branch of technology. Airtel did have basic licenses also in some circles but preferred not to pursue with CDMA technology like Tata and Reliance. The choice of technology has helped their planners concentrate on GSM and its upgrades. These service providers were also among the first to upgrade networks to EDGE and further on to WCDMA/HSPA. With the exception of Airtel the other two have not gone for BWA spectrum.

5.11.6 The Dual technology Private Players: Reliance and Tata

Reliance and Tata both have started their journey from basic license operation and have launched full scale CDMA networks across the length and breadth of the country in 2002/2003. The starting technology was CDMA 2000 1X and after coming to the market has given a tough fight to the incumbent GSM players with innovative offerings.

Down the line, both operators opted to offer service in the GSM family too. In an interview to a business daily in 2008, Tata Teleservices have put forward the reasoning that as far as spectrum allocation is concerned CDMA technology operators do benefit. CDMA operators are allotted half of the spectrum being allotted to GSM players with the policy planners admitting that the technology is more spectrum efficient. The other rationale is GSM being more widespread the cost of capital cost is substantially lower than the capital expenditure incurred for deploying CDMA networks.

Tata went in for a MVNO type model with Virgin Mobile of UK. This was the first instance of an existing operator tying up for brand franchisee with a global brand. The virgin brand targeted the youth segment while Tata Indicom marketed itself to the mass market. For the same equipment and technology two brands came into being targeting the wireless market. MVNO per se is not allowed as per regulation and competitors alleged that rules were bent to allow this arrangement.

5.11.7 More Entrants:

Aircel, S tel, Uninor, Shyam- Sistema (MTS), Loop, Datacom (Videocon): 2007

As a result of a policy decision by the government, new licenses were announced to facilitate entry of more players into the market. These players went in for the GSM family of standards to leverage the price points for equipment and services facilitated by the widespread GSM family of standards in the Indian market. Another factor is to leverage into the network effects of the installed GSM base. The only exception is MTS which went in for the 3GPP2 family of standards- CDMA 2000 1X tying up with the Shyam group. MTS also initially targeted the voice market but quickly changed course and started focusing on the wireless data market which evidently generates better revenue than voice users.

5.11.8 The Data players: 3G and BWA

Most of the existing GSM and dual technology players participated in the 3G auctions through an e-auction process with no new player entering the fray. Except for BSNL+MTNL combination no other operator won pan India licenses. The government PSUs got the spectrum without bidding for the same through a government preferential policy for public sector telecom units.

The BWA auctions which was held immediately after saw new winners in Reliance, Tikona, Qualcomm and Augere. Reliance emerged as only player besides the BSNL+MTNL combine with right to cover the entire country with BWA technology. The other players in 3G and BWA picked up selective circles primarily based on price points, strategy for spectrum, data, coverage, budget and existing presence. Qualcomm being a technology vendor emerged as a surprise winner in the BWA auction participated on the grounds of promoting the LTE form of technology. Auctions were held in 2010 but BSNL because of its special handling by DOT launched WIMAX technology in 2009.The auctions provided a chance to interested players to offer LTE as an alternative to WiMAX.

Technology wise the Indian service providers can be arranged as below (till beginning of 2012). Some of the LTE operators are yet to launch services.

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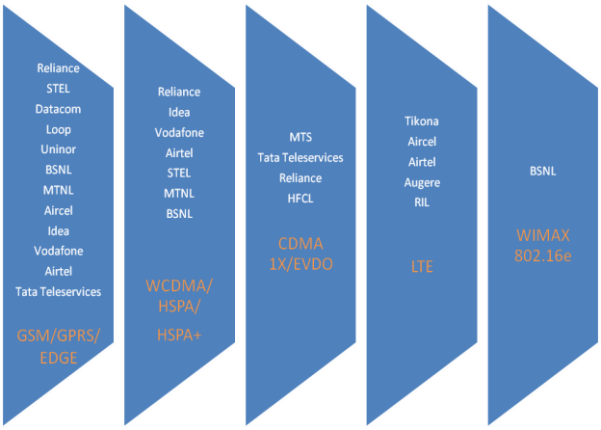
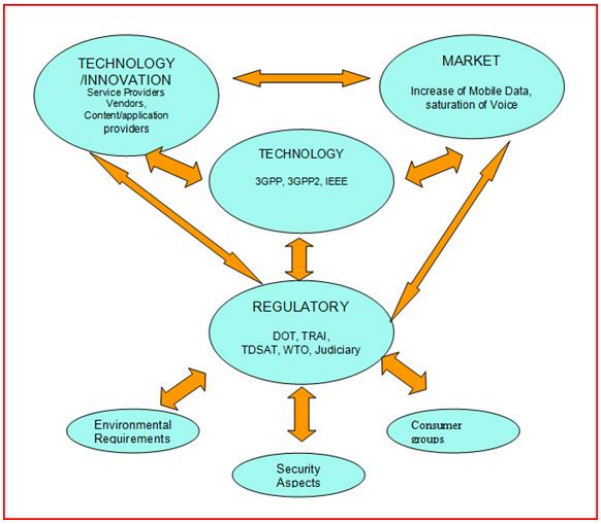


5.11 Institutional Framework for the Mobile Ecosystem in the Indian Context

Considering the different forces in play, the framework for the Indian wireless industry can be represented in the following manner. The Regulatory and Policy function is influenced by different pressure groups. Internal security is as aspect that plays heavily in the minds of the policy makers. Provision of legal interception of voice calls, data packets, websites, content and video needs changes and modifications in the hardware and software operating in the operators' deployed infrastructure. In view of the security consideration, different bodies exert pressure to have their needs to be addressed. Similarly as the consumer is becoming more aware of his surroundings and concern for health and environment, he also influences the policy and regulators to consider risk of radiation from towers, handsets and disposal of equipment beyond its life when formulating policies and guidelines.



SECTION 6: CONCLUSION AND FURTHER RESEARCH

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Wireless technology has advanced rapidly and continues doing so; however it has not made the disruptive technological breakthrough as in the league of the IP domain. There the transition in terms of IPV4 to IPV6 in increasing the 32 bit addressing to 128 has enabled the addition of billions of IP addresses which was a limitation in IPV4.

Each newer avatar of wireless technology like LTE and EVDO/HSPA to previous versions helped pump in more information in the same spectrum in what is known as spectral efficiency (bits/ Hz). The requirement to meet the burgeoning need for data in India will be a challenge in the foreseeable future. As operators grapple with less spectrum and try to push technology to the limits by upgrading existing technology deployments for better spectrum efficient offerings and going for a mix of technologies like Wi-Fi with 3G and LTE, CDMA with GSM. A harmonious mix of technologies for offerings to end customers and to meet different customer segments do seem to hold potential as vendors and operators try to achieve technological leadership in their domains. The need to differentiate will help push innovations in the hyper competitive wireless industry in India. What has been achieved for voice will spur the need for similar success stories in the mobile data front.

While India has a successful story to demonstrate as far as mobile voice is concerned with GSM and CDMA standards, the industry has under gone quite a few upheavals. The transition story does seem to indicate that it would continue on multiple fronts as mobile data becomes more permeating in terms of technology, in terms of policies and regulations and in meeting expectations in QoS leading to better end user experience. The complex web of players and actors in the Indian wireless industry portends challenges as well as spur innovation in the future.

The study attempted to delve into the how, what and when of the mobile industry evolution in India. The study presents the different actors in the 3 stages of the development of the wireless industry and their roles in the complex web of transition and evolution. This study could be of use to students and researchers of the wireless industry in India. This can also be of interest to the policy makers, operator and vendor community. The study of Indian wireless industry presents a case of a developing country without any substantial base of mobile infrastructure manufacturing, no history of wireless standard development but which through interplay of overarching government policies, private and public investment and ingenuity managed to make the masses of India aware and accessible to the benefits of telecom use. Both the major camps of wireless technology families GSM and CDMA helped to increase the tele density in the country for voice. As data usage is expected to pick up in coming times, the role of technology, competing standards for deployment and resolution of various issues faced by the industry with more pro active and clearly defined polices from the government to stimulate demand for data along with an independent regulator can help the growth. The Indian mobile market has a lot of potential left and the actions and reactions of the various actors will determine the course to be charted. The study of these forces will also help students and researchers in other developing countries who are facing similar dilemmas of choosing technology and standards to push the benefits of wireless voice and data technology to the citizens.

Future research can dwell on comparing India with other similar countries to learn more about the evolution path and to see whether developing countries without much or no manufacturing base follow similar paths. Quantitative analysis on certain aspects related to this evolution path on a country specific or multi country perspective could throw more light to substantiate the case study method.

REFERENCES

[1] Sanjay Kumar Singh (2008): The diffusion of mobile phones in India: Elsevier, Telecommunications Policy, Volume 32, Issues 9-10, October-November 2008

[2] Prakhyath Makam: New Generation Mobile Communication-4G, The Vision, Challenges and Research Activities: Wipro technologies, www.psu.edu

[3] Rekha Jain, Rajanish Dass (2001): Research and action agenda for a national broadband initiative in India: 8th International Telecommunications Society (ITS) Asia-Pacific Regional conference ,Taiwan 26-28 June 2011:Covergence in the Digital Age. Http:/hdl.handle.net/10419/52317

[4] Ashok Jhunjhunwala, Anaka Aiyar (2007): Case Study: Connecting Rural India with Broadband Wireless: Department of Electrical Engineering, IITM, Chennai, India

[5] Varadharajan Sridhar (2007): Growth of Mobile Services across regions of India ; Journal of Scientific and Industrial Research, Vol 66, April 2007, pp 281-289

[6] Chendroyaperumal, Chendrayan and Raj, Mohan (2011): Stock Behavior of Indian Telecom Companies During Pre-2G-Scam and Post-2G-Scam: SSRN: http://ssrn.com/abstract=1883592

[7] T.H. Chowdary, (2002): Diminishing the digital divide in India: info, Vol. 4 Iss: 6, pp.4 – 8

[8] Manas Bhattacharya (2004): Telecom Sector in India: Vision 2020: Paper submitted to the Committee on India: Vision 2003, Planning Commission, Government of India

[9] Stephen D.Mcdowell,Jenghoon Lee (2003): India's experiments in mobile licensing: Telecommunications Policy 27 (2003) 371-382, www.elsevier.com

[10] Pankaj Sinha, Akshay Gupta (2011): Analysis of WiMAX/Bwa licensing in India" a real option approach: MPRA paper no 31280 posted 11 June 2011/07:09

[11] Sara Biancini (2010): Behind the Scenes of the Telecommunications Miracle: An empirical analysis of the Indian market: CESIFO Working paper No 3286 category 11: Industrial Organisation, December 2010: www.CESifo-group.org/wp

[12] Jan Markendahl,Bengt G Molleryd (2012): On Network deployment strategies for mobile broadband services taking into account amount of spectrum and fixed line penetration-comparison of network deployment in Europe and India: The regional ITS India Conference 2012, New Delhi, February 22-24,http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-77441

[13] Sangeeth Varghese (2007): Reliance Infocomm's strategy and impact on the Indian mobile telecommunication scenario: cprsouth.org

[14] Venkata Praveen Tanguturi, Fotios C. Harmantzis (2006): Migration to 3G Wireless broadband internet and real options: The case of an operator in India. Elsevier, Telecommunications Policy Volume 30, Issue 7, August 2006, Pages 400-419, ISSN 0308-5961

[15] Ramesh Subramanian (2008): The (Continuing) Evolution of India's Telecom Policy: Communications of the IIMA, 2008 Volume 8, Issue 3

[16] Janaki Srinivasan (2010): From telecom switches to telecenters Changes in the 'telecom for development discourse in India (1947-1999), ICTD '10: Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development

[17] Harsha Vardhana Singh, Anita Soni, Rajat Kathuria (2003): Telecom Policy Reform in India: India and the WTO, World Bank, 2000 - siteresources.worldbank.org

[18] Subhashish Gupta (2011): Cellular Mobile in India: competition and policy: Working Paper No 353 Indian Institute of Management, Bangalore

[19] Moazzem Hossain, Rajat Kathuria (2004): Telecommunications Reform and the Emerging "New-Economy: DSA Conference: 10-12 September 2003, University of Strathclyde, Glasgow, UK

[20] Sunil Jain (2008): Regulatory Roulette: Business Standard India 2009

[21] Rekha Jain (2004): A Review of Telecom Regulatory Authority of India's tariff and interconnection regulation, iitk.ac.in

[22] Kishore C. Dash (2005): Players and the Deregulation of State-Owned Enterprises: The Case of Telecommunications in India: Department of Global Business Thunderbird, The Garvin School of International Management, Glendale, Arizona

[23] Payal Malik (2004): Regulation and Investment: Case Study of the Indian Telecommunications Industry: LIRNEAsia, regulateonline.org

[24] Amitava Dutta, Varadharajan Sridhar (2004): Modeling Growth of Cellular Services in India: A systems dynamics approach: Proceedings of the 36th Hawaii International Conference on System Sciences-2003

[25] Fernandez Jackson and Kakani, Ram Kumar (2007): Understanding Dynamics in a Evolving Industry: Case of Mobile VAS in India: Great Lakes Herald Journal, 2007 SSRN: http://ssrn.com/abstract=953510

[26] Rohit Prasad, Varadharajan Sridhar (2009): Allocative efficiency of the mobile industry in India and its implications for spectrum policy, Telecommunications Policy, Volume 33, Issue 9, October 2009, Pages 521-533, ISSN 0308-5961

[27] Varadharajan Sridhar, Rohit Prasad (2011): Towards a new policy framework for spectrum management in India, Telecommunications Policy, Volume 35, Issue 2, March 2011, Pages 172-184, ISSN 0308-5961

[28] C.Sambasiva Rao (2009): Next Generation Mobile Telephony in India A critical appraisal of 3G spectrum allocation: ASCI Journal of Management 38(2): 46-56

[29] R.S. Jain (2001): Spectrum auctions in India: lessons from experience: Telecommunications Policy 25 (2001) 671-688, www.elsevier.com

[30] Varadharajan Sridhar, Thomas Casey, Heikki Hämmäinen (2011): Systems Dynamics Approach to Analyzing Spectrum Management Policies for Mobile Broadband Services in India: International Journal of Business Data Communications and Networking (IJBDCN), Volume 8, Issue 1.

[31] David Lewin, Val Jervis, Chris Davis, Ken Pearson (2008): assessment of spectrum management policy in India: A final report to the GSMA: Plum Consulting

[32] Kumar Alok (2011): 3G Spectrum Auctions in India: A Critical Appraisal: ://epw.in/epw/user/viewAbstract.jsp. . SSRN: http://ssrn.com/abstract=1764882

[33] Ankit Mittal (2007): India as a Playground for Spectrum Management in developing nations: CITNE Student Paper PGP-2007-1001

[34] Rakesh Basant, G.R.Ramadesikan (2002): Communication Standards Adoption in Developing economies: Issues and Options for India: IIMA Working Papers, 2003 - en.scientificcommons.org

[35] Ashok Jhunjhunwala, Bhaskar Ramamurthi, Timothy A. Gonsalves (1998): The Role of Technology in telecom expansion in India: Volume: 36, Issue: 11, Communications Magazine, IEEE, Communications Magazine

[36] L.F. Pau and J. Motiwala (2007): India: a case of Fragile Wireless Service and Technology Adoption? www.erim.eur.nl , International Journal of Mobile Communications, Volume 6, Number 3/2008

[37] Chun Liu, Krishna Jayakar (2012): Evolution of Telecommunications policy-making: comparative analysis of China and India: Telecommunications Policy 36 (2012) 13-28, www.elsevier.com

[38] Baer,, Walter S., Bar, Francois, Hong, Yu, Mailland, Julien, Mehta, Aalok and Movius, Lauen (2011): Comparing Mobile Openness: Case Studies of United States, United Kingdom, France, China, India & Brazil: TPRC 2011. , SSRN: http://ssrn.com/abstract=1986365

[39] Keval J.Kumar, Amos O. Thomas (2006): Telecommunications and Development: The Cellular Mobile Revolution in India and China: of Creative Communications, November 2006 vol. 1 no. 3 297-30

[40] David Tilson, Kalle Lyytinen (2005): Making broadband wireless services: An actor-network study of the US wireless industry standard adoption: Working paper on Information Systems, 5(21), Case Western Reserve University, Sprouts

[41] Kalle Lyytinen & John L.King (2002): The cradle of the wireless revolution: the emergence and evolution of cellular telephony: Telecommunications Policy 26 (2002) 97–100

[42] Ping Gao, Jan Damsgaard (2007): A Framework for understanding mobile telecommunications market innovation: A case of China: Journal of Electronic Commerce Research, VOL 8, NO 3, 2007

[43] Chao, Fu-Cheng & Veijalainen, Jari, (2011): The latent regulations for the TD-SCDMA development in: Socio-technical translation process study for the third 3G standard,22nd European Regional ITS Conference, Budapest 2011: Innovative ICT Applications - Emerging Regulatory, Economic and Policy Issues 52143, International Telecommunications Society (ITS).

[44] Chao Fu-Cheng, Caleb (2012): Generation Information Technology (NGIT) Networks Implementation - A Social-technical analysis for the telecom policy goals and its sustainability study in China's 12th Five Year Plan (FYP, 2011-2015): Department of Computer Science and Information System, University of Jyvaskyla, Finland. Http://ssrn.com/abstract=2048618

[45] Youngjin Yoo, Kalle Lyytinen, Heedong Yang, The role of standards in innovation and diffusion of broadband mobile services: The case of South Korea, The Journal of Strategic Information Systems, Volume 14, Issue 3, September 2005, Pages 323-353, ISSN 0963-8687

[46] Dong-Hee Shin, Hyunseung Choo, Khisu Beom (2010): -Technical dynamics in the development of next generation mobile network: Moments of translation processes beyond 3G: Technology Forecasting & Social Change

[47] Bong Gyou Lee, Jeong Ho Kwak, Ki Youn Kim, Seong Jin Kim (2009): Technical innovation and 3.5 mobile phone generation: Lessons from Korea, Telecommunications Policy, Volume 33, Issues 5–6, June–July 2009, Pages 296-308, ISSN 0308-5961

[48] Shin, Dong-Hee, (2011): Evaluation of Korean information infrastructure policy 2000-2010: Focusing on broadband ecosystem Change: 8th Asia-Pacific Regional ITS Conference, Taipei 2011: Convergence in Digital Age 52310, International Telecommunications Society (ITS)

[49] Youngjin Yoo, Kalle Lyytinen, Heedong Yang (2005): The role of standards in innovation and diffusion of broadband mobile services: The case of South Korea, The Journal of Strategic Information Systems Volume 14, Issue 3, September 2005, Pages 323-353, ISSN 0963-8687

[50] Vladislav V, Fomin, Ping Gao (2005): Transition towards 3G in the Nordic and Baltic regions: a research framework: Proceedings of the EURA Workshop, June 2-3, Tallinn 2005

[51] David Tilson, Kalle Lyytinen, (2006): The 3G transition: Changes in the US wireless industry Telecommunications Policy, Volume 30, Issues 10–11, November–December 2006, Pages 569-586, ISSN 0308-5961

[52] David Tilson, Kalle Lyytinen (2005): Making broadband wireless services: An actor-network study of the US wireless industry standard Adoption: Working paper on Information Systems, 5(21), Case Western Reserve, Sprouts

[53] Endre Grotnes, Steinar Kristoffersen (2008): The development of mobile services-the impact of actor groups in the standardization process: Department of Informatics, University of Oslo, Norway

[54] Neil Mcbride (2003): Actor Network Theory and the adoption of mobile communications: Geogra 88 No 4 (Oct 2003) pp 266-276

[55] Kalle Lyytinen, Vladislav V Fomin (2002): Achieving high momentum in the evolution of wireless infrastructures: the battle over the 1G solutions, Telecommunications Policy, Volume 26, Issues 3–4 April–May 2002, Pages 149-170, ISSN 0308-5961

[56] Vladislav V. Fomin, Arturas Medeisis, Daiva Vitkute Adzgauskiene (2011): The Role of Policy in the Development of Cognitive radio Systems Co Evolutionary Perspective: VYTAUTAS MAGNUS UNIVERSITY, KAUNAS, Lithuania

[57] Jan Damsgaard, Carol Kelleher (2009): What drives the innovation, diffusion and adoption of mobile services? An analysis of four alternative:studies: ://books.google.co.in/books?id=w0ebQwAACAAJ

[58] Barbara Bigliardi 1, Alberto Ivo Dormio 1 & Francesco Galati (2011): Successful co-opetition strategy: evidence from an Italian consortium: International Journal of Business, Management and Social Sciences Vol. 2, No. 4, 2011, pp. 1-8

[59] www.trai.gov.in

[60] www.dot.gov.in

[61] www.coai.com

[62] www.auspi.in

[63] www.airtel.in

[64] www.rcom.co.in

[65] www.tatadocomo.com

[66] www.tataindicom.com

[67] www.bsnl.co.in

[68] www.ideacellular.com

[69] www.itu.int

[70] www.cdg.org

[71] www.gsma.com

[72] www.gsacom.com

[73] http://businesstoday.intoday.in/story/bye-cdma,-hello-gsm/1/834.html Accessed on 30th Sept 2012

[74] www.industowers.com

[75] www.hindubusinessline.com

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