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Twilight of Voice, Dawn of Data: The Future of Telecommunications in India

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Abstract

These are exciting times for telecommunications in India. On the one hand, we have the entry of one of the largest business houses in India into the cellular mobile services market on a large scale, leading to increased competition as well as mergers and acquisitions. On the other, we see exciting new technologies being unveiled and we stand at a point in time where technologies such as Internet of Things, big data, cloud computing, 5G and artificial intelligence are starting to get deployed. Among other concerns, this has raised issues of privacy and net neutrality. We discuss all of these and other related matters. We also, provide a short history on telecommunications in India and discuss technological issues, manufacturing, infrastructure and market development. We round of with a set of recommendations on policy making.

Keywords: Telecommunications, India, Infrastructure, IOT, 5G, privacy

JEL classifications: L 86, L 96, O 53

1. Introduction

A cursory glance at the history of the development of telecommunications in India reveals periods of turmoil followed by periods of relative calm. Through all these twists and turns the industry seems to have enjoyed fairly strong growth and development. During each crisis, there are predictions about the impending death of the industry. Somehow, though, often through government intervention, the industry recovers and chugs along contentedly for a few years before the next crisis erupts. We seem to in the midst of another crisis at the moment. The lack of certitude about whether it is a crisis or not is related to the different narratives offered by different stakeholders and cellular service companies. For some it is a splendid opportunity while for others it spells looming disaster. For the public at large, offers and discounts are raining down even though the spectre of consolidation and higher prices in the future is a distinct possibility. So, this is an opportune moment to ponder about the past and the future of the telecommunications industry.

The one striking feature of the present situation in the telecommunications industry is the dwindling relevance of voice. True, all cellular mobile companies still derive 52%[1] revenues from voice but the rivalry has switched to data. Most telecom companies have seen marginal increases in the number of mobile subscribers over the last few years. For example, according to the Telecom Regulatory Authority of India there was a minor reduction of 0.32% in the total number of wireless[2] subscribers in September 2017[3]. Clearly, additional subscribers are difficult to find. The urban tele-density for both wireless and wireline stood at 173.15, indicating that a number of customers had more than one connection. Even though this number does not indicate full coverage in urban areas, it suggests saturation. The rural tele-density in

[1] Voice and Data, August 2017

[2] Wireline subscribers are a small part of total subscribers. The total number of subscribers is 1,206.71 million, implying a tele-density of 93.40. The total number of wireline subscribers stood at 23.67 million and declined by 1.37%.

[3] http://www.trai.gov.in/sites/default/files/PIR_July_Sept_28122017.pdf

contrast stands at 56.71, which is a cause for worry. It may be that families and friends often share phones but even then, the number suggest that a significant section of the population lacks access. So, one might find the current obsession with data somewhat puzzling. The grim truth is that those lacking access are not commercially viable, probably too poor or too remote or both. It is also a pointer to our failed universal service obligations (USO) policy.

Given the excitement surrounding data it would be useful to look at the state of internet penetration in the country. According to the Telecom Regulatory Authority of India (TRAI), the internet subscriber number stood at 429.23 million and the number of broadband subscriber at 324.89 million. Thus, the internet penetration rate is 33.22. There is an urban-rural divide in internet access as well, where the urban penetration rate is 73.65 while the rural rate is 14.62. The urban penetration rate probably over estimates access as richer household have numerous avenues of access such as fixed access, dongles and smart phones while the poor often have none. One striking feature is that 95% of internet access is wireless, so mobile phone operators provide most of the access. The latest entry of Reliance Jio with attractive offers and the subsequent responses by rivals have led to lower prices, stimulating demand. Most operators have seen a decline or small additions to their subscriber base with the exception of Reliance Jio which added 15.25 million new subscribers. It has quickly become the fourth largest operator in terms of subscriber base. There are some rosy forecasts on internet penetration: Cisco predicts that by 2021 the number of internet users will be 829 million[4]. So, we could be looking at a penetration rate[5] of about 60 in four years' time.

The future development of telecommunications will have to deal with the advent of new technologies. Already, 5G is on the cards in mobile communications and we could soon see early steps in the Internet of Things (IOT), where devices communicate with each other. More and more applications including network functions will move to the cloud ushering a new era in cloud computing. All these developments will require enabling policies and proper

[4] http://indianexpress.com/article/technology/tech-news-technology/internet-users-in-india-to-double-by-2021-says-cisco-4696154/

[5] The number of internet subscriptions divided by the total population.

regulation. One can imagine the security and privacy issues involved when our refrigerators and washing machines are connected to groceries and maintenance centres. Adding to the problem is the use of analytics and big data. Data from our refrigerators could be, for instance, used to predict purchasing patterns and also to infer the likely state of our health. Privacy and security concerns, already plague social media. IOT and other associated technologies are likely to compound these problems.

We shall provide a snapshot of the historical developments in telecommunications in India and then follow up with a look at the state of development in the different sectors, such as mobile telephony, telecom towers, phone manufacturing and others. Recent developments as in unified licensing, virtual network operators (VNO) and spectrum trading will be discussed as will be the issues covering manufacturing. This will require a detour into a short discussion of Standard Essential Patents (SEP) and FRAND (fair, reasonable and non-discriminatory) terms.

Given the growing importance of data we will need to discuss other issues such as cloud computing, big data and analytics, privacy, net neutrality and security. We will not spend too much time on these issues but we cannot afford to neglect these either, given their importance in the way we access and use the internet. Other aspects of phones cell phones and the internet such as their impact on society will not be covered here[6]. Again, this is not too deny its importance. Hardly a week goes by without a reported death of a young person while attempting to take a selfie. Finally, there is the issue of consumer protection that is important but will be neglected in this paper. In their rush to get the largest number of customers mobile phone operators often skimp on service. Once upon a time these firms were notorious for bad connections, euphoniously known as call drops.[7] With data, there are concerns with speed and connectivity and consumption of data is ambiguous from the viewpoint of the consumer.

We should also emphasize the role of convergence and divergence. On the product side, it is noticeable that a number of products such as televisions, laptops, smartphones and personal

[6] The interested reader should consult (Jeffry and Doron (2013)

[7] The problem still exists even after TRAI's efforts to bring it down.

computers now have similar features. One could watch a television show using any of these devices. The advent of the digital age has resulted in the death of the audio compact disk industry and also nearly killed the camera industry. If products converge then their businesses should converge as well. The effect is difficult to predict. Services are also converging and we could soon be in an era of fixed-mobile convergence.

Convergence could lead to more competition and lower prices or to the consolidation of different industries. At the same time because of personalised data being available firms can now offer customized versions of the generic product for individuals. It is difficult to know if the price I am paying for a flight bought online is the same as that paid by others. Thus, it would be difficult to compare prices across the same product consumed by different individuals. While customisation is beneficial this will allow firms to extract more of the value from the customer and lack of comparison may result in higher prices.

This paper looks at historical developments and discusses new technologies that are emerging. The plain old telephone system (POTS) has evolved into a very complex beast. It would be better to call it the Information and Communications (ICT) Industry. It also operates within a complex web of political, social and institutional structures which affect its development and in turn is affected by it. It is a very dynamic industry and technology development is rapid and innovations occur at a fair clip. It is not possible to capture all the nuances and describe all the constituent parts that make it up in a short article. The issues that we have chosen to discuss are those we felt to be most important and are necessarily idiosyncratic of the authors. Innovations such as digital payments have been left out and we refer very briefly to the important issue of spectrum. The interested reader can consult the bibliography to get a more substantial view.

1. The telecommunications industry: structure and history

Most people, when they think about the telecommunications industry, concentrate only on mobile, broadband and mobile phones. These are the three products that most of us consume or want to. Among many consumers, particularly the young and well heeled, the latest smart

phone and its features are the stuff of conversations. However, the telecommunications sector comprises of many other products and services. Figure 1 shows the essential components of the telecommunications industry.

We are most familiar with making calls and accessing the internet locally or when travelling. There are other services that telecom service firms offer such as value-added services (VAS) and National Long Distance (NLD) and international long distance (ILD). An example of VAS is IPTV or mobile banking. Finally, large businesses need telecom solutions that are tailor-made for them. For one, they need to have secure voice and data connections, connecting their offices around the world using International Private Leased Circuits (IPLC). To provide these services telecommunication companies have to build telecommunication networks which can be wireline or wireless or a combination of both. Wireline may include old twisted copper cables for last mile access or optic fibre. Similarly, wireless could be deployed using different standards such as GSM & IS-95 (2G), IS-2000 & UMTS (3G) or LTE (4G). Our networks are a combination of 2G, 3G and 4G. To build these networks firms need infrastructure such as towers, power generators, cables and switches. They also need spectrum to be able to deliver these services in case of wireless. Consumers need to own phones, computers or other devices to avail of these services.

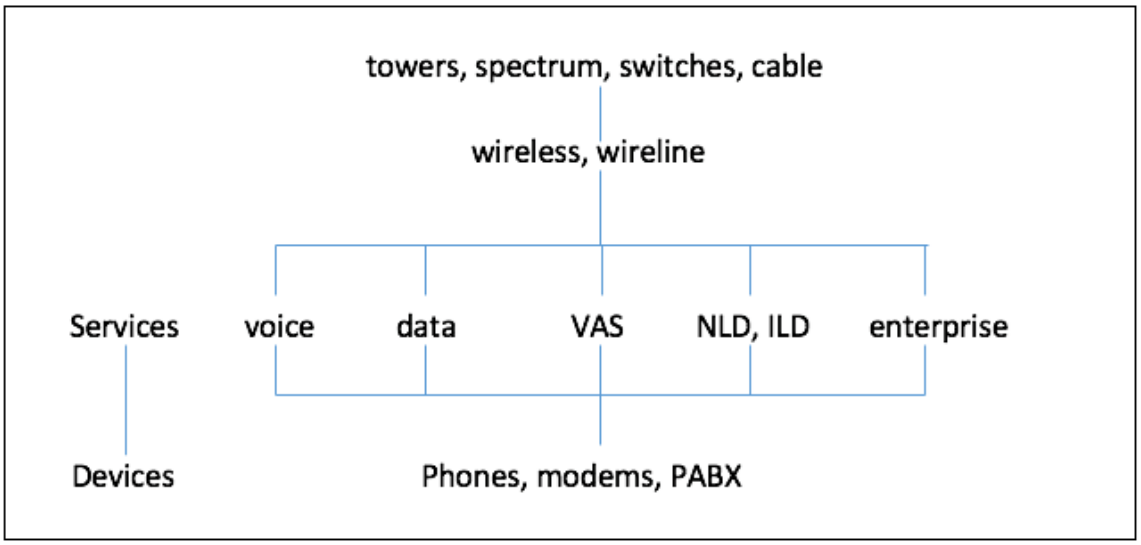

Figure 1. Structure of Telecommunications

Voice is a stand-alone service. It needs no supporting services. The same is not true about data which needs content. For entertainment and news, we need websites such as YouTube, Facebook and news websites such as NDTV. To avail government services, the government needs to build its own websites and regularly update them. Most government websites are ill designed and not configured for mobile phones. To avail health, education and banking services there have to be vendors providing such services. So, the flourishing of data requires an eco-system. We need cheap and speedy connections, cheap smart phones and computers and good content. This would require among others an efficient governance structure for the industry.

2.1. Governance Structure

Unfortunately, the governance structure of telecommunications is also complex. Ostensibly it has two regulators, the Telecom Regulatory Authority of India (TRAI) and the the Department of Telecommunications (DoT) within the Ministry of Communications and Information. The DoT is a part of the government while the TRAI is an independent regulator. Their powers are different but they affect each other. The TRAI can regulate prices but cannot grant licenses which lie within the powers of the DoT. Similarly, allocation of spectrum lies with the DoT. The TRAI's decisions can be appealed with the Telecom Dispute Settlement Appellate

Tribunal (TDSAT) which can be appealed to high courts. There are a host of other entities who also affect the telecommunications industry. An attempt at harmonization is made through the Telecom commission[8] which includes secretaries from ministries that are closely concerned. However, given that ICT products and services permeate the economy a broader structure would be useful. Other regulators such as the competition commission of India can also come into play. Since production of phones and other equipment involve patented technologies, intellectual property (IP) laws are also involved. Standard essential patents (SEP) need to be available at fair, reasonable and non-discriminatory terms (FRAND). Obviously, industrial policies and policies on importing, particularly with regard to tariffs, have a significant impact on the production of equipment. Thus, some degree of coordination is necessary for the industry to flourish.

The complexity does not end here. Mobile phones now touch virtually every aspect of our lives with the promise to do even more. Take the case of using mobile applications (apps) to hire taxis from aggregators such as Ola and Uber. Regular taxi services have complained about the lack of regulation of such services and consumers have raised safety concerns. Local government agencies such as the transport department and the police have had to get involved. Already we have mobile payments and rudimentary mobile banking which come under regulations for financial services. We should expand into education and health which will bring its own quota of regulations from the concerned ministry. So, while mobile telephony and access to the internet holds huge promise for better access to services and uplifting of a large section of society it will need wise and coordinated policymaking to bring it into fruition. The current silo system of policy making by the government is unlikely to work.

2.2 A Short History

We will now provide a very short history of telecommunications in India. We will not provide and extensive account. The interested reader can consult Desai (2006) or Sridhar (2011). Liberalization of telecommunications started in early 1990s with the opening up of licenses to

[8] http://www.dot.gov.in/profile

first basic telephony and then cellular mobile. At the time, the DoT was interested in getting private firms to start operations in local calling. However, local calling was cross-subsidised by national long distance and international long distance, keeping prices artificially low. The National Telecom Policy, 1994 was the first attempt by the government to tentatively liberalize the telecom sector. The TRAI was formed in 1997 and soon came out with its first telecom tariff order, in which it rationalized prices lowering NLD and ILD prices and increasing local calling prices. This was challenged by the DOT which questioned the TRAI's powers to set prices, claiming that it was a policy decision and policy making was beyond the purview of the TRAI. .

Montesquieu's classical work the Spirit of the Laws (De L'Esprit des Lois) first published in French in 1748 forms the foundation of modern democratic principles of separation of powers – the legislative, the executive and the judicial. Viewed from this institutional lens, it was questioned as to how a regulatory body such as the TRAI could handle both executive and judicial functions. It may however, be noted that some notable exceptions remain to this resilient principle of separation of powers. European Commission in the European Union for instance enjoys both administrative and judicial functions and on the other side of the Atlantic, in the US, the Federal Trade Commission (FTC) undertakes both administrative as well as judicial functions. Design of institutions is a complex question which requires a detailed analysis - a subject beyond the scope of the present paper.

Table 1. Major historical events

Date	**Event**
1851	First telegraph between Kolkata and Diamond Harbour
1882	Opening of Telephone Exchange in Kolkata, Chennai, Mumbai
1914	First automatic exchange in Shimla

1927	Radio-telegraph system established between UK and India
1947	Foreign Telecommunication companies nationalized
1975	Department of Telecom separated from Indian Post
1985	Establishment of MTNL
1992	Bids invited for cellular services in four metros
1994	First National Telecom Policy (NTP 1994), Radio-paging etc. opened to private participation, DOT issues guidelines for private sector entry into basic services, 8 cellular licenses for metros finalized after litigation for 2 years
1995	DOT invites bids for basic, cellular and PMRT services, first spectrum auction in 900MHz, mobile licenses are issued around the country, VSNL starts internet services
1996	5 successful bidders for basic telephony
1997	TRAI formed
1998	License default by mobile companies, internet services opened to private firms
1999	TRAI first Tariff Order, NTP 1999, revenue sharing, government third operator
2000	NLD license, TDSAT formed, DOT corporatized as BSNL
2001	Fourth operator, second auction
2002	ILD license, USO policy
2003	Unified Access Service Licensing, IUC charges introduced
2004	Spectrum allocation administrative
2007	CDMA and GSM licensing

2008	2G (alleged) spectrum scam, 1800 MHz, 800 MHz
2010	3rd auction for 3G-2100 MHz, BWA-2300 MHz (Infotel-Reliance Jio saga)
2011	Mobile number portability, NOFN
2012	All UASL licenses after 2008 illegal, NTP 2012, Unified Licensing, 4th auction 800 MHz, 1800 MHz, unsuccessful auction
2013	Failed auction for metros 900MHz, 1800 MHz, 800 MHz MTS, Unified license issued
2014	Repeat auction 900 MHz, 1800 MHz, Mergers and acquisitions guidelines issued
2015	Auction for non-metros 900 MHz, 1800 MHz in 3 circles, 800 MHz Reliance Jio, 2100 MHz, All India MNP
2016	VNO guidelines, Reliance Jio entry, Spectrum Sharing Guidelines
2017	Vodafone-Idea merger, Reliance Jio buys RCom mobile services

The clamour died down after a time and two cellular mobile licenses each were issued to 23 circles including 4 metros, graded in to three categories A, B and C according to the attractiveness of their markets. These circles we approximately the same as the geographic states in India. Thus, the DoT created 23 artificial markets. The TDSAT was set up to separate judicial actions from administrative actions of the TRAI. Decisions of the TRAI could now be appealed to the TDSAT. Very soon after the mobile telecom companies started operations they discovered that their revenues fell far short of their bids for getting licenses and they would have to default on their promised schedule of payments. This was the first problem that confronted the nascent liberalised telecommunications industry.

The problem was eventually solved by moving to a regime of revenue sharing whereby the mobile telecom operators would pay their license fees as a percentage of their revenues over a period of time. In effect, the government became a stakeholder in the mobile telecommunications industry. Higher revenues would imply higher income for the government. This shift to the new regime was achieved with the intervention of the prime minister and required considerable effort. It is not clear that the DOT played any role in averting the crisis. After this crisis, the industry recorded impressive growth for the next ten years, but with occasional hiccups. The next big crisis occurred with the alleged 2G scam. The government decided to allocate spectrum on a first-come-first-served basis. However, there were allegations that firms were allocated spectrum out of turn in exchange for bribes. Eventually all licences were cancelled by the supreme court.

The salutary effect of that event was the strict use of auctions in all future spectrum allocations. A disquieting side effect was the importance placed on the amount raised through spectrum auctions by the government. By this yardstick the 3G auctions were considered a resounding success, though the effect of high bids could ultimately be felt by consumers in the form of high prices. On the regulatory front the TRAI finally decided to club licenses from all types of services into one by issuing unified licenses. This ended the possibility of using one type of license to provide a different type of service. An example is the use of fixed-mobile licenses using CDMA technology to provide full mobility. Further auctions followed, and the regulator has removed more restrictions on different types of services allowed and has allowed more flexibility. The latest storm to hit the industry was the entry of Reliance Jio with very aggressive introductory offers. Predictably, this led to another round of price reductions and consolidation in the industry. There were also concerns about the heavy debt burdens that telecommunication companies were required to service. The concerns seem to have abated for a while, though they may erupt again leading to another round of government reaction.

2.3 Telecommunication Services

For the longest time when we thought of telecommunication services we thought of talking to each other, which, in telecommunications parlour is called voice. Now, we are also interested in downloading and watching news, entertainment and sports and that is known as data. Essentially,

any form of digital communication is data while analogue communication is voice. So, if we make calls using voice-on-internet-protocol (VoIP) on WhatsApp then that is data. The telecommunication services sector can be decomposed into voice services which comprise 52%, data (20%), Value Added Services (VAS) 4% and others (24%)[9]. The total telecom services revenues stood at Rs. 283,197 Cr in 2016-17. Voice can be further decomposed into Wireless (GSM + CDMA), Fixed and others including Multiple Systems Operators (MSO) operators such as Hathway and Internet Service Providers (ISP) such as ACT. Post liberalization we have witnessed the steady decline in fixed services particularly in wireline, on account of the steady decline in the fortunes of the incumbent state operators BSNL/MTNL. This has been accompanied by the rise of mobile services operators such as Airtel, Vodafone and Idea.

For some time, though even voice revenues have remained steady or shown low levels of growth. Last year was the first time we saw a decline in voice revenues. This was accompanied by a decline in revenues from fixed services. The revenues from wireless stood at Rs. 194,750 Cr, down from Rs. 199,947 Cr, while that from fixed services stood at Rs. 21,104 Cr down from Rs. 21,712 Cr. Other services showed a growth of 10.5%. However, the picture gets clearer when we look at voice and data separately. We notice that revenues of mobile voice have decreased by 1.7%, while that of mobile data services have decreased by 4.4%. The decrease in the revenues of mobile voice is part of a trend, indicating saturation of the urban and rich households. The decrease in data revenues is due to price decreases due to increasing competition and possibly by the entry of Reliance Jio with its introductory offers. It is interesting to note that subscriber numbers for mobile data increased by 85% in the same time period. Fixed voice declined by 30.3% from Rs. 5,582 Cr while that of fixed data increased by 7.10% from Rs. 14,467 Cr. This indicates that fewer consumers are opting for fixed voice phones and are indeed giving them up. At the same time, there has been an increase in the number of people purchasing laptops or desktops that typically use fixed internet connections. Also, better-off households are using fixed connections for entry into their homes through modems and routers and then converting them into Wi-Fi, thereby being able to connect to multiple devices using one fixed connection.

[9] Voice and Data, August 2017

The top four telecom services companies are Airtel (26%), Vodafone (15%), Idea (13%) and BSNL (12%) by revenue, in 2016-17. They are followed by Reliance Communications (RCom), Aircel and others that have shares in single digits. The share of Reliance-Jio, which is a new entrant is 13.3%. The number of subscribers already matches the market leaders, but revenues are likely to be low and possibly negative given the costs of promotional prices and entry. The real effect will be known only after a few years. In the mean while it has sparked off a wave of mergers and acquisitions in the industry. Vodafone is merging with Idea. Airtel has acquired Tata's mobile services and Telenor and Reliance Jio has acquired RCom's mobile service business. In the future, we may have only 4 telecom service providers, Airtel, Vodafone-Idea, Reliance Jio and BSNL/MTNL.

2.4 Technology

Telecommunications technology is quite complex, and we have no intention of explaining it in detail. We shall provide a simple exposition in order to help the reader understand the rest of the paper. We can think of two types of services that are available for both voice calling and accesses to the internet: fixed and mobile. The names are suggestive in themselves. The usual image of fixed access is that of a phone attached to a pair of twisted copper wire which has graced our homes for years before the advent of mobile technology. These wires would be connected to the telephone exchanges and calls would be placed with the help of switches. The copper wires can also be sued to provide rudimentary access to the internet. Nowadays fixed access is still provided through special wires from providers such as Airtel, but their can carry a large volume of data. Cellular mobile on the other hand uses the electromagnetic spectrum to carry information: voice or data. The requirements are spectrum and the necessary equipment: cell phones, towers, switches and backhaul. We use cell phones to connect to towers and from there to the person called, through switches. In the case of internet access, we connect to the tower and then to the server. Towers have to connect with each other and also to different servers and we would expect them to carry a lot of information. There is another method of transmitting data, that through optical fibres. This method is useful for transferring huge amounts of data but is also cumbersome to set up and relatively expensive. We would expect backhaul to be achieved by these cables. Mobile technologies also can now approach levels of performance of fibre optical cables.

Mobile technology can be of two types GSM and CDMA. GSM is prevalent in most countries around the world. In India, we have in the past used CDMA for fixed-mobile access, a situation where the phone is fixed but uses mobile technology. The experiment was not successful, and we have relatively few operators that provide CDMA connections. GSM in turn can be 2G, 3G and 4G. These represent improvements in technology. It is noteworthy to mention that these improvements are not uniform and incremental as one may conjecture. Evolution from 3G to 4G has for instance been very disruptive when compared with 2G. Likewise, 5G with a connected economy and internet of things (IOT) is expected to be the most disruptive of them all. To take a quantum leap and make up for the lost ground in earlier technological evolutions, the debate about standard essential patents (SEPs) and standard setting as we will discuss in section 2.8 below is pivotal.

Most of our phones use 2G or 3G for voice and in metros and large cities we use 4G for data. Another term that we often encounter is LTE standing for Long Term Evolution[10]. Connectivity standards for 4G as set by the ITU specified 100Mb/s for mobiles and at 1Gb/s for stationary uses such as mobile hotspots. These targets were difficult to achieve so any improvement towards 4G was dubbed LTE. So even if our phones say 4G it is not technically 4G. The next improvement is 5G[11], for which technical standards have not been set yet, but would likely involve speeds of 20 Gb/s.

2.5 Spectrum and Auctions

The allocation of spectrum has been a reason for controversy for many reasons. When the cellular mobile services were rolled out spectrum[12] was allocated through administrative mechanisms. Usually, administrators looked at the credentials of the firms applying for spectrum, also called a beauty contest, and some other method such as first-come-first-served. Obviously, the award of spectrum was amenable to manipulation and the 2G scam case of 2008, highlighted the dangers.

[10] http://www.3gpp.org/technologies/keywords-acronyms/98-lte

[11] https://www.sdxcentral.com/5g/definitions/what-is-5g/

[12] Prasad and Sridhar (2014) provide an extensive treatment on the subject.

After that all allocation of spectrum has been through auctions. This has raised new problems. The 3G auctions raised large amounts of money for the government and it seems to have become common wisdom that a good auction should be lucrative for the government. This is a dangerous fallacy. The main function of an auction by the government should be the efficient use of resources. The spectrum should be allocated to firms that can make the best use of this spectrum. Bidding for spectrum helps this process, but the money raised has to be financed by the firms in some manner. It is possible that firms may take on large amounts of debt to pay for spectrum. The other problem is the fixation with minimum reserve prices. To make sure that firms don't win auctions at bids that are too low and a situation where the government does not make money, bids have to be higher than a prescribed threshold. The tendency is to make reserve prices as high as possible but that reduces the number of participants and the efficiency of the auction.

2.6 Telecommunication Infrastructure

When we pick up a phone to make or answer a call we are usually unaware of the technology and the complexity of the infrastructure required to enable that conversation. At a simple level, we are aware that there are towers which allow us to connect and most of us have had to deal with billing errors and customer service representatives. This is just the tip of the iceberg. The total Telecom infrastructure market was worth Rs. 224,452 crores in 2016-17. This not much less that the market for services, that we are much more familiar with. The market can be further divided into Carrier Infrastructure, Enterprise Communication, and Devices. Further subdivisions within each segment is possible. Carrier infrastructure will include Telecom Towers, Access Equipment such as switches and software. Enterprise Communication will include PBX systems and desk phones and Devices will include mobile phones, tablets and data cards. We will not venture into a discussion on the entire gamut of all types of infrastructure. Instead we will concentrate on towers within Carrier Infrastructure and Mobile phones within devices since these are somewhat contentious issues.

2.6.1 Telecom Towers

All of us are familiar with Telecom Towers that dot the landscape in our cities and in rural areas. Most of these are considered eyesores but without these our mobile phones would not work. An

added concern in recent years is the amount of radiation emitted by these towers and the effect on health. A different concern is the amount of energy required by towers. Since we wouldn't want our mobile phone services to be disrupted by power cuts tower companies have to make arrangements for standby power in the form of diesel generation sets raising environmental concerns, not to mention the added cost of generation that is passed on to consumers. From the point of view of tower companies, problems with land acquisition and right-of-way loom the largest. Local officials are often loath to provide the clearances required to raise more towers. The dilemma is that consumers want better connections and fewer call drops which require more towers with the existing technology. At the same time, they want fewer towers and less pollution. Certainly, most people would not want to live next to a tower. Technology is rapidly evolving to allow towers to handle more calls, but the problem persists. The other solution is to have more Wi-Fi hotspots, but that route seems to have been missed in India. Except for hotels, airports and a few restaurants there are very few Wi-Fi hotspots. Wi-Max technology also seems to have fallen into disuse.

Towers and other non-electronic equipment such as BTS shelters, power supplies and generators are also referred to as passive infrastructure. There are currently 454,521 towers and 15 lakh BTS and the total revenue earned in 2016-17 was 61,388 Cr. Most telephone carriers in the early days started off with owning their own towers, a practice which still continues. However, now there are independent tower companies such as Indus Towers and also third-party tower operators. The industry is in a process of consolidation through mergers and acquisitions such as the purchase of Viom by American Tower Company (ATC). The top 3 tower companies are Indus Towers, ATC and Bharati Infratel with revenues of 17,482 Cr, 7,949 Cr and 6,085 Cr respectively in 2016-17. The remaining firms which include Reliance Infratel and BSNL-MTNL among others account for 25,271 Cr. One of the recent regulatory initiatives has been to allow passive infrastructure sharing. Thus, carriers may use each other's towers for placing calls. This has led to fewer towers being needed and less diesel consumed. On the flip side this has raised the possibility of moving on to sharing of other network facilities (active versus passive sharing) and the possibility of forming cartels. So, sharing is useful for cost optimization but carry within it the seeds of cartelization.

2.6.2 Phone manufacturing

The ability to make and receive calls as well as to access the internet requires phones or tablets and personal computers. Consequently, the price of phones is important. We can separate out phones into feature phones and smartphones. The terminology is a bit ambiguous, however, the essential difference is that smartphones allow access to the internet and the use of apps. They also allow the use of messaging services such as WhatsApp that use the internet to send messages and also to make voice calls. Smartphones have added features such as high-quality cameras for taking pictures and making videos. Typically, they consume much more power and need to be recharged more frequently. Feature phones contrary to their name are used mainly to make phone calls and sending messages. They do not have a large display screens and are largely functional. They are popular among the poor and people living in rural areas since they are cheaper and have relatively long battery life. This is important for people who do not have easy access to electricity.

The mobile phone market amounted to Rs. 114,154 by revenue in 2016-17. The top 3 companies were Samsung, Apple and Lenovo. Interestingly they only command 48% of the market the rest being cornered by a variety of brand name manufacturers such as Panasonic and LG, Indian companies such as Intex and Karbonn and Chinese manufacturers. The interesting development over the last few years was the emergence of Indian smartphones that soon captured the lower and middle end of the smartphone market. They also captured the feature phone market where they ousted the likes of Nokia and where they remain firmly ensconced. The upper end of the smartphone market remains the preserve of Samsung, Apple and Lenovo among others. In the recent past, they in turn have been replaced by Chinese manufacturers such as Vivo, Oppo and Xiomi. This has been a cause of heartburn among some industry commentators[13]. Among the problems faced by Indian manufacturers have been falling afoul of intellectual property laws. Since this issue is important and can affect the whole industry we devote a separate section to it.

2.7 Recent regulatory changes

[13] https://economictimes.indiatimes.com/magazines/brand-equity/how-indian-smartphones-are-losing-out-to-china/articleshow/58906705.cms

https://gadgets.ndtv.com/mobiles/features/how-indian-smartphone-makers-lost-the-war-against-chinese-companies-1747112

In this section, we will describe the most significant regulatory changes that have occurred in the recent years. Regulatory changes can impact the telecommunications industry profoundly. As remarked earlier the industry has multiple regulators. Here we will concentrate on the regulations coming out of the DOT. The official industry regulator TRAI is consulted on most issues but what proportion of its suggestions make their way into regulations by the DOT is unclear.

2.7.1 Unified licensing

The most significant of the recent regulatory changes that transpired has been the movement to unified licences. As recounted earlier the government first gave out licenses for basic (local) telephone services to private operators. After that it gave out licenses for 23 circles including four metros for starting 2G services using Global System for Mobile (GSM) technology. GSM is a form of time division multiple access (TDMA) technology that sends multiple compressed data streams in their own time slots. Most European countries use GSM but not Japan. GSM technology uses the 900 MHz or the 1800 MHz spectrum bands. Earlier phones that were specifically designed for GSM would not work in countries that relied on other technologies such as code division multiple access (CDMA). This highlights the interdependence between access technology (GSM versus CDMA), type of spectrum and devices (type of phones, tablets). All of these needs to be aligned for effective delivery of service.

These licenses were given on a first-come-first-served basis but along with a certain amount of controversy. After a few years the government issued licenses for fixed-mobile services using CDMA technology. The phones were expected to be fixed in that one could not carry the phone around like a GSM phone but the connection between the phone and the switches would be provided through mobile connections. At that point, mobile phones were seen to be the preserve of the rich, given very high calling charges. Fixed wireline phones were expected to provide connections to the multitude. The problem was that laying down cables to provide fixed phones proved too costly. A way out was to use mobile technology as an alternative to cables also known as wireless in local loop (WLL). Thus, the government issued licenses at a lower cost for fixed-mobile phones using CDMA technology for use on 800 MHz spectrum. Obviously, GSM phones

would not work, so the operators would have to provide phones as well as connections for the service to succeed. This was the first instance of bundling services and equipment in India.

Soon there were reports that operators were violating their terms of service and providing some if not full mobility. The fixed phones were small enough to could be carried around plugged in at different locations. The GSM operators were rightly peeved at the appearance of a mobile service that was a cheaper, though imperfect, substitute for their own services. In the commotion that followed the TRAI and the government decided that licenses would now be technologically neutral. So, the government learnt a lesson that picking and choosing technologies and generally micro-managing an industry that is so innovative, flexible and dynamic is fundamentally doomed to failure. The culmination of this knowledge accretion led to unified licensing.

The National Telecom Policy (2012) in recognition of the developments of the telecommunications sector decided to "orient, review and harmonise the legal, regulatory and licensing framework in a time bound manner to **enable seamless delivery of converged**[14] services in a technology and service neutral environment."[15]It recognises convergence in services, networks and devices. It also strives to dissolve the fragmentation of markets through different licenses for different geographies, technologies and spectrum allocations through its "one nation-one license" policy. This requires the implementation of unified licensing and the delinking of spectrum from licenses. It asserts that "spectrum shall be made available at a price determined through market related processes." This presumably refers to auctions but does not explicitly say so.

Based on TRAI recommendations the Government issued detailed guidelines for grant of unified licence (UL) in January 2014. The UL is further categorised to meet the needs of different operators based on intended service roll out, scale and scope of the operations. Unified Licenses can be for any one or more of the services listed below:

- Unified License (All Services)
- Access Service (Service Area-wise)

[14] emphasis in the original document

[15] http://meity.gov.in/writereaddata/files/National%20Telecom%20Policy%20(2012)%20(480%20KB).pdf

- Internet Service (Category-A with All India jurisdiction)
- Internet Service (Category-B with jurisdiction in a Service Area)
- Internet Service (Category-C with jurisdiction in a Secondary Switching Area)
- National Long Distance (NLD) Service
- International Long Distance (ILD) Service
- Global Mobile Personal Communication by Satellite (GMPCS) Service
- Public Mobile Radio Trunking Service (PMRTS) Service
- Very Small Aperture Terminal (VSAT) Closed User Group (CUG) Service
- INSAT MSS-Reporting (MSS-R) Service
- Resale of International Private Leased Circuit (IPLC) Service

To take care of existing licences the government offered a "migration path"[16] from their existing license to a unified license. Operators could keep their current services or add additional services by paying an extra fee. Most of the operators took advantage of this migration path offered. As an example, Reliance Jio, who was licenced to provide only broadband services through the spectrum obtained in broadband wireless access (BWA) auction in 2010, migrated to full UL licence allowing it to provide any service across the country,

2.7.2 Mobile Virtual Network Operator (MVNO)

In a converged system, the same network can provide various services. These services can even be independent of the network layer. The service provider can be one operator whereas network provider is another operator. As an example, WhatsApp runs its services independent of the network provider, although it is not a managed service. However, if service providers work in coordination with the network provider various managed services can be provided. To allow services by such providers who not necessarily own any network, the Government in May 2016 created another category in UL regime called UL(VNO). Such virtual network operators (VNO)

[16] Guidelines for grant of unified license

are treated as extension of network service operator. These VNO licences can be issued under any service or any area as provided in UL regime mentioned in previous section.

2.7.3 Merger and Acquisition

To facilitate the consolidation of the telecom, sector the Government issued merger and acquisition guidelines in February 2014. For access services, like Vodafone and Airtel, the merged firm should not have a market share that exceeds 50%. If it does, it would have to reduce its market share to below 50% within a year. Market share will be calculated on the basis of subscriber numbers and revenue. The apparent rationale for this regulation is that no operator is allowed to hold more than 50% of the spectrum in a particular band[17]. While, the move was welcomed for enabling consolidation in the telecommunications industry it is not clear whether it will create more problems. On the institutional front it could pit the DOT against the CCI and mandating businesses to reduce their customer base or to not provide new connections because they violate market share conditions is dubious. Clearly, we have some distance to go before we embrace market based principles.

2.7.4 Spectrum Sharing

In line with the National Telecom Policy 2012, the government allowed spectrum sharing among operators in September 2015. Given the paucity of spectrum that network operators were complaining about this move ought to be welcomed as it would allow the more efficient use of spectrum. Spectrum sharing refers to several operators using each other's spectrum to provide access services. An example would be Vodafone using Airtel's spectrum to provide services in New Delhi. Spectrum sharing can be a form of active sharing (sharing of network elements that are used to provide access) in contrast to passive sharing (sharing of towers and power). Even though there are reports of large cost savings and better service it raises anticompetitive concerns.[18]

[17] http://www.dot.gov.in/sites/default/files/DOC200214_0.pdf

[18] BEREC-RSPG report on infrastructure and spectrum sharing in mobile/wireless networks

As per the spectrum sharing guidelines sharing is allowed among access service providers holding access service licences. These include Cellular Mobile Telephone Service (CMTS), Unified Access Service License (UASL), Unified License (Access Service) (UL(AS) and Unified License (UL).[19] However, the guidelines allow sharing of spectrum only in the same band and spectrum sharing is not permitted if the two operators have their spectrum assignment in different bands.[20] For example, if an operator had obtained spectrum in 2100 MHZ band, it can share the spectrum with only those operators who also possess spectrum in 2100 MHz band. Also, an operator who have been allotted spectrum through administrative processes is allowed to share the spectrum only after paying one-time spectrum charge to the government. As with the merger guidelines the sharing guidelines seem to have many stipulations that seem unnecessary and more likely to impede sharing. Some of these are meant to induce fairness, such as the one regarding spectrum allotted administratively.

2.7.5 Spectrum Trading

Spectrum trading can be thought of as a type of spectrum sharing but largely based on some market mechanism. The market mechanism could be of different types such as sale, buy-back, leasing and mortgage[21]. In selling we could use bilateral negotiation, auctions (by the owner of the spectrum), brokerage or exchange (similar to a stock market). Obviously, it is meant to increase efficiency of the market. An owner of spectrum should sell it to another person who can make the best use of it. If the value of the spectrum to another operator is higher than the value to the owner, there is a possibility of trade and better utilization of the spectrum. It should also reduce barriers to entry as new entrants can always buy spectrum from the incumbents (provided they are willing to sell) and not have to wait for another auction.

The DoT in October 2015 allowed trading of spectrum among operators. Only outright sale is permitted, and spectrum trading is allowed only between two access service providers holding the

[19] Different licenses were given at different times. Most access service operators now have UL.

[20] http://www.dot.gov.in/sites/default/files/2015_10_13%20Sharing-WPC_1.pdf?download=1

[21] http://www.ictregulationtoolkit.org/toolkit/5.1

same licence as CMTS, UASL, UL(AS) and UL license. Trading is allowed at each circle level covering the entire circle. Government has also fixed the minimum block size for trading the spectrum in each of the bands. For example, in 2100 band a block size of 2x5MHz can be traded. Only that spectrum which has been obtained through a market mechanism (e.g. auction) can be traded. Further the spectrum can be traded only after two years of its acquisition. Administratively assigned spectrum cannot be traded and is allowed for trading only after it gets liberalised by paying the requisite fee which is linked to auction discovered prices.

2.8 SEP and FRAND

The SEP and FRAND debate is particularly important in light of the converged telecommunications sector where different devices will need to talk to one another to function optimally. In technical terms, it means that the devices need to be interoperable and thus, standard setting becomes very central to the discussion about the future of Indian telecoms. By collectively adopting a particular standard, the manufacturers are assured that it will be the most widely adopted standard, which they can license from the SEP holder on FRANDly terms and that the product incorporating that particular standard will be interoperable with other complementary devices.

Interoperability of devices and collaborative standard setting for 2G, 3G and 4G standards in the more mature economies played an instrumental role in stimulating the growth of smartphones to 'integrate international markets' and augment the demand for 'investment in innovation and standardization'.[22] Standard setting positively impacts both static (that is price-led competition) and dynamic competition (that is innovation-led competition). It also minimizes transaction costs and prevents wasteful expenditure across different competing standards. As regards, 2G, 3G and 4G, the debate is very important in the Indian context, considering that the issue of FRAND royalty has been central to the recent smartphone wars and till date six important cases concerning SEPs have been filed before the Indian courts and the Competition Commission of India (CCI).

[22] Tsilika, Huawei v. ZTE in Context – EU Competition Policy and Collaborative Standardization in Wireless Telecoms, at pgs 155-158

The final outcome of these cases, as well as how India's first telecoms Standard Setting Organization (SSO), Telecommunications Standards Development Society (TDSI) steers the process of standard setting will have a direct impact on consumer welfare. It will affect the quality and value of new and more innovative products being introduced as well as the average price of smartphones that the users will pay in the future. The TDSI[23] will largely focus on standard setting for the 5G technology, which is expected to play a key role in the connected economy and internet of things.[24] The decisions in the six cases will have a more immediate impact in terms of the prices that the consumers pay for their smartphones - particularly the ones manufactured by Indian manufacturers such as Intex and Micromax. TDSI's role becomes more prominent from a long-term perspective and it is also expected to help India leapfrog the technology curve. This is on account of the fact that the licensee fees paid by the producers of smartphones is passed on to consumers as part of the final retail price.[25] At the same time, if upstream producers[26] are not adequately compensated for their innovation efforts, they have diminished incentives to innovate and license it to downstream producers.[27]

The second noteworthy aspect is that in the current scenario, in the smartphones value chain, Indian manufacturers are predominantly active in the downstream.[28] Manufacturing low value and cheaper versions of smartphones ensures accessibility to a wider range of price-sensitive consumers and promotes price-led competition. To promote dynamic innovation-led competition,

[23] TDSI was set up, based on the recommendations of India's telecom regulatory authority (TRAI).

[24] Indian Telecommunications Industry Analysis, India Brand Equity Foundation dated October 2014; Prof. Abhay Karandikar, Economic Times article dated 16 August 2012, India needs Umbrella Body in Telecom Standards to foster Creation of IPR and Develop Indigenous Products; See also the website of Telecommunications Standards Development Society, India http://www.tsdsi.org.

[25] In this section, we analyse the market for smartphones, as a two level market, where the upstream market concentrates on research and development of patents. The downstream market comprises of the smartphone manufacturers.

[26] reference to innovators, vertically integrated companies as well as patent assertion entities engaged in R&D

[27] Gerard Llobet & Jorge Padilla, *The Optimal Scope of the Royalty Base in Patent Licensing*, dated 25 June 2014, available at https://papers.ssrn.com.

[28] To the knowledge of the authors, no Indian smartphone manufacturers have any SEPs registered to their name.

upstream market for Research and Development (R&D) becomes very important. Moreover, downstream producers have different incentives and revenue models as distinguished from pure upstream players or vertically integrated players. To illustrate, pure downstream players such as Intex's revenue model is direct sale of smartphones to the final consumers; whereas a pure upstream player's revenue model is to maximize its revenue by seeking maximum royalties for its SEPs. Considering the different incentives, reverse hold-up by pure downstream players or hold-up by upstream players can potentially be in their respective interests to maximize their profits.

The incentives of a vertically integrated (VI) enterprise may be slightly complex to understand. VI producers may be more inclined to engage in cross-licensing with one another and thus, bring peace to the patent wars. In 2012, European Commission and the US Department of Justice unconditionally cleared the Google/Motorola merger as it was expected to promote patent peace by promoting cross-licensing. Additionally, it was expected that any potential anti-competitive effects could be effectively dealt with through ex-post competition law enforcement.[29]

In the Indian context, considering the principal presence of downstream producers, the meaning of FRAND[30] and a potential good methodology for calculating FRAND royalties is very central to the ongoing debate on SEPs. The terms fair, reasonable and non-discriminatory have been subject to considerable interpretation. Expression 'non-discriminatory' in FRAND means that the SEP holder cannot discriminate between similarly situated users.[31] This does not preclude the SEP holder from engaging in offering different licensing conditions – in other words, price

[29] *See* Case No COMP/ M.6381 Google/Motorola Mobility, available at http://ec.europa.eu/competition/mergers/cases/decisions/m6381_20120213_20310_2277480_EN.pdf; Statement of the Deppartment of Justice's Antitrust Division on its Decision to Close its Investigations of Google Inc's Acquisition of Motorola Mobility Holdings Inc. and the Acquisitions of Certain Patents by Apple Inc., available at https://www.justice.gov/opa/pr/statement-department-justice-s-antitrust-division-its-decision-close-its-investigations.

[30] The expression FRAND in more frequently used in India and the European Union and RAND is more commonly used expression in the US. The two expressions, though are 'substantively equivalent'. David J Teece, Edward F Sherry and Peter C Grindley, *On the "non-discrimination" aspect of FRAND licensing: A response to the Indian Competition Commission's recent orders*, IIMB Management Review, available online 19 October 2017 at https://www.sciencedirect.com/science/article/pii/S0970389617305098#fn0420. Accessed 01st December 2017.

[31] Decision Unwired Planet/ Huawei [2017] EWHC 711 (Pat).

discrimination, does not lead to the assumption that the SEP holder is engaging in discriminatory conduct.[32]In the US, Judge Robert in Microsoft v. Motorola held that a 'reasonable royalty' is one that takes into account 'the contribution of the patent to the technical capabilities of the standard' and the value of the relevant technology to 'the implementer and [his] products'.[33]

In India too, the issue of FRAND royalty has been central to the smartphone wars and till date six important matters concerning SEPs have been filed before the Indian courts and the CCI. Three involve complaints by Micromax, Intex and iBall before the CCI, where the complainants alleged that Ericsson abused its dominant position by refusing to license 2G and 3G SEPs on FRANDly terms. iBAll's argument was slightly more expansive then Micromax and Intex's wherein it argued that Ericsson's 'strict and onerous' terms in the non-disclosure agreement, including the request for adjudication in Singapore and the choice of law as Swedish laws, was abuse of dominance within the meaning of section 4 of the Indian Competition Act.[34] Ericsson in turn filled a writ petition before the Delhi High Court against Micromax and Intex. In addition, Ericsson also brought a case against Xiaomei Technology alleging that the Chinese manufacturer infringed its 2G and 3G SEPs.

Interestingly, the CCI and the High Court of Delhi have diverged on the subject of calculation of royalties. Whereas the Delhi High Court used the value of the downstream product as a suitable base to calculate FRAND royalty that Micromax and Intex should pay to Ericsson[35], the CCI

[32] David J Teece, Edward F Sherry and Peter C Grindley, *On the "non-discrimination" aspect of FRAND licensing: A response to the Indian Competition Commission's recent orders*, IIMB Management Review, available online 19 October 2017 at https://www.sciencedirect.com/science/article/pii/S0970389617305098#fn0420. Accessed 01st December 2017.

[33] Microsoft v. Motorola, US District Court

[34] *See* Micromax Informatics Limited v. Telefonaktienbolaget LM Ericsson (Publ), Case No. 50 of 2013, available at http://infojustice.org/wp-content/uploads/2013/12/CCI-Case-no-50-2013.pdf; Intex Technologies (India) Limited v. Telefonaktienbolaget LM Ericsson (Publ), Case No. 76 of 2013, available at http://www.cci.gov.in/sites/default/files/762013_0.pdf; M/s Best IT World (India) Private Limited (iBall) v. . Telefonaktienbolaget LM Ericsson (Publ), Case No. 04 of 2015, available at http://www.cci.gov.in/sites/default/files/042015_0.pdf.

[35] This is an interim decision of the court subject to final decision. *See* Ericsson v. Micromax and Ericsson v. Intex

inclined towards using smallest saleable patent-practising component (SSPPC) as the appropriate basis for calculation of FRAND royalty. Based on this, the Delhi High Court directed Micromax to pay an interim royalty (pending final settlement) at the rate of .08-1.3% of the net selling price of the devices.[36] In the Intex decision, the Delhi High Court reached a similar decision.[37] A third recommended methodology is looking at the 'incremental value addition' by the patent.[38] This means that the paid royalties should be based on the additional value that the SEP brings to the product. Yet another recommended methodology is assigning equal and proportional value to all the SEPs.[39] Thus, for example if a chip has 1000 SEPs, each SEP is assigned a value of 1 and if a firm has 200 SEPs – this means that firm will receive 20% of the royalty.

The key question, and also one of the more frequently debated one, is taking due consideration of specifics of the ICT sector which among these possible approaches is most suitable to calculate the FRAND royalty? Empirical evidence indicates that choice of final device as distinguished from particular component within the device may under certain circumstances be anti-competitive.[40] In an innovation, calculating RAND royalty on the basis of 'smallest saleable patent-practising

[36] Telefonaktiebolaget LM Ericsson (Publ) v. Competition Commission of India and another, W.P. (C) 464/2014 & CM Nos. 911/2014 & 915/2014 dated 30 March 2016, available at http://lobis.nic.in/ddir/dhc/VIB/judgement/30-03-2016/VIB30032016CW4642014.pdf, accessed 01st December 2017.

[37] Telefonaktiebolaget LM Ericsson (Publ) v. Intex Technologies (India) Limited, I.A. No. 6735/2014 in CS (OS) No. 1045/2014. Judgment dated 13 March 2015, available at http://lobis.nic.in/ddir/dhc/MAN/judgement/16-03-2015/MAN13032015S10452014.pdf, accessed 01st December 2017.

[38] Joseph Farrell, John Hayes, Carl Shapiro and Theresa Sullivan, *Standard Setting, Patents and Hold-Up*, 74 Antitrust Law Journal 603 (2007) stating that the "the proportionality default could be modified, either ex ante or ex post based on information about the ex-ante incremental values of the essential patent."

[39] Philppe Chappatte, FRAND Commitments – The Case for Antitrust Intervention, 5(2) European Competition Journal 319, 340-343 (2009)

[40] Joseph Kattan, *The Next FRAND Battle: Why the Royalty Base Matters*, 1 CPI Antitrust Chronicle March 2015

unit'[41], Judge Holderman calculated a royalty of 9.56 pence per unit for a 19 SEPs that read on 802.11 Wi-Fi standard.[42]

On the other hand, using end-user product as a royalty base has been recommended as a more practical approach considering the ease of ascertaining the price of final product and overall improvement and system-wide effect on account of its incorporation in the standard.[43] This also assures that the chosen royalty base is neutrally decided at an arm's length, as the final price of the downstream product is a decision independent of the royalty negotiations between the SEP holder and downstream implementer.[44] Overall, even though empirical evidence and legal decisions indicate the advantages as well as the shortcomings associated with the two commonly employed techniques, considering the dynamics of the Indian telecoms sector, CCI's approach of using SSPPC may better meet the requirements of the industry.

Another frequently raised question is whether SEP licensing and FRAND commitments be treated as a competition law issue, an IP issue or a breach of contract.[45] Contract law is perceived as a 'promising alternative to antitrust enforcement'[46] as a FRAND commitment is a voluntary contractual obligation that an SEP holder makes to the SSO. The licensee - the implementer of the

[41] And not against the end or final product.

[42] In re Innovation IP Venture, LLC Patent Litigation, Case No. 11 C 9308, District Court for the Northern District of Illinois

[43] Kirti Gupta, *FRAND in India: Emerging Developments*, Antitrust in Emerging and Developing Countries, Conference Papers at pg 11

[44] David J Teece, Edward F Sherry and Peter C Grindley, *On the "non-discrimination" aspect of FRAND licensing: A response to the Indian Competition Commission's recent orders*, IIMB Management Review, available online 19 October 2017 at https://www.sciencedirect.com/science/article/pii/S0970389617305098#fn0420. Accessed 01st December 2017.

[45] David J Teece, Edward F Sherry and Peter C Grindley, *On the "non-discrimination" aspect of FRAND licensing: A response to the Indian Competition Commission's recent orders*, IIMB Management Review, available online 19 October 2017 at https://www.sciencedirect.com/science/article/pii/S0970389617305098#fn0420. Accessed 01st December 2017.

[46] Bruce H Kobayasshi and Joshua D Wright, *Federalism, Substantive Preemption and Limits on Antitrust: An Application of Patent Holdup*, 5(3) Journal of Competition Law & Economics 469 (2009).

standard - is a third-party beneficiary of this contract.[47] Moreover, in contract law, there is no need to prove the dominance of the patent holder – which is a pre-requisite for ex-post competition law enforcement.

3. Technological Developments

Predicting the future is hazardous. However, since there is so much discussion nowadays of new technological developments such as artificial intelligence and automation and what it means for the future that we cannot but help wade in as well. There are different ways to talk about the future. The grandest existing vision is that of the fourth industrial revolution associated with Klaus Schwab[48]. He describes the first industrial revolution as that of involving steam power and mechanization, the second involving electricity and mass production and the third involving electronics, information technology and automation.

He sees the fourth industrial revolution as building on the third but with extraordinary impact. The range and scope of innovation will be so fast that it will affect all aspects of our lives and change it in unimaginable ways. In particular it will result in "blurring the lines between physical, digital and biological spheres." The speed of change is exponential rather than linear and it is disrupting every industry and will transform "production, management and governance." He sees a scenario where billions of people are connected by smart devices with unlimited processing power, storage and knowledge. This will be augmented by innovations in "artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, material science, energy storage and quantum computing." Whether, this scenario comes to pass is unknown. It is however important to note that large parts of the word envisioned will require communication between people and devices and between devices themselves at very high speeds and the exchange of large amounts of data. Thus, we will devote some space to discussing 5G and the Internet of Things (IOT).

[47] Microsoft v Motorola

[48] https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution

We should note that while the fourth industrial revolution may just be a vision, countries are gearing up to prepare for this eventuality. An example is Korea, which scores very high on the ICT development index.[49] They envisage the fourth industrial revolution as a production and consumption revolution driven by the possibility that goods will become "intelligent." Already we have cars that have inbuilt sensors which can sense mechanical and electrical failures and alert drivers and to impending problems and urge maintenance. This type of intelligence can be embedded into a large number of products. We are talking about smart meters, dustbins, refrigerators, lights and many more. Thus, production and consumption will not remain distinct activities and will be combined. Again, one can take the example of cars. Earlier, first a car was produced and then sold to a consumer for the consumption process to start. In the future consumption will involve the services of the car, possibly driverless, which will need constant involvement of the producer. In a way, most products will become services and the manufacturing component will reduce in value. The actual production of the car body and its attendant parts will become subservient to the sensors and communication devices and the software needed to keep driving. The Koreans are also aware that the fourth industrial revolution can bring with it social problems or aggravate existing ones. At stake are issues like unemployment, inequality and social strife.

In this section, we will discuss technologies that have already evolved and are on the cusp of being deployed or are already being used. Big data and machine learning is already in use and is expanding rapidly. Cloud computing cannot be termed a new technology anymore but its use in telecommunications technology is novel. 5G and IOT are new but deployment could be as near as 2020. The government has committed Rs. 500 crores to be spent on research and development among the ministries of Communication, Electronics and IT and Science and Technology and has set up a High-Level Forum on 5G India 2020 in September 2017.[50]

3.1 Internet of Things (IOT)

[49] Production and Consumption in the Fourth Industrial Revolution

[50] http://www.thehindubusinessline.com/info-tech/5g-in-india-govt-sets-up-body-for-5g-eyes-rollout-by-2020/article9873596.ece

We have mentioned IOT a number of times in this paper. Roughly, we have described it as communication between machines. We will now give a more comprehensive definition and discuss the technology. There are a number of terms in vogue that seem to refer to the same idea as IOT, machine to machine (M2M), Internet of Everything (IOE), Smart Societies, cities, grids and so on. This plethora of names reflects the evolution of the concept of IOT. In its earliest avatar, it referred to communication between machines, presumably without human interaction and was called M2M. The OECD (2011) defines the term as "devices that are actively communicating using wired and wireless networks, that are not computers in the traditional sense and are using the Internet in some form or another." It goes on to add that M2M communication is only one part of "smartness". We need to combine cloud services and remote operation and interaction with M2M. A more recent definition[51]highlights the importance of four main elements for IOT. These are data analytics, cloud computing, data communication and sensors and actuators. Together they make up the IOT eco-system.

A simple illustration of IOT that already exist is the HealthPatch health monitor.[52] It can monitor your vital signs remotely and alert your physician or relatives in the event of some illness. Similarly, we should expect innovations and products in manufacturing, education, agriculture and so on. Communication can exist between inanimate objects such as plants, between machines and between humans and machines or other humans. So, the possibilities are enormous. What we need is an eco-system that nourishes the introduction of new devices and innovation.

[51] OECD 2015

[52] https://beebom.com/examples-of-internet-of-things-technology/

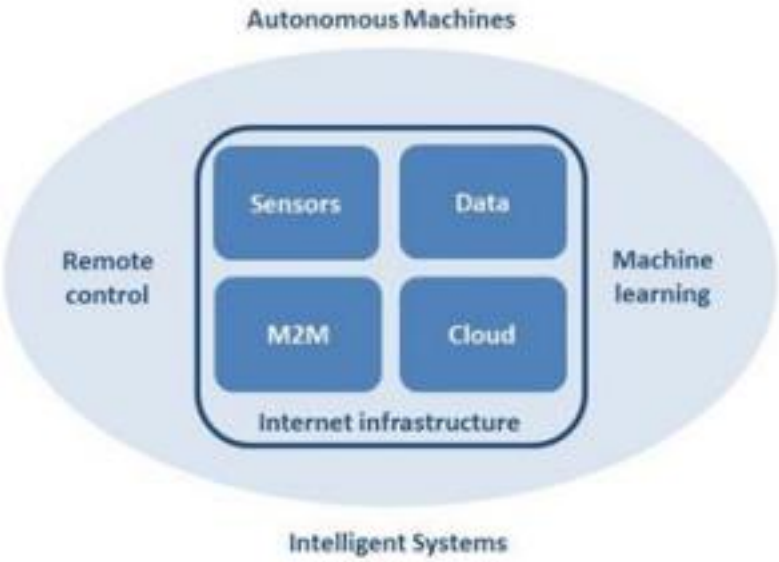

Figure 2: The IOT eco-system

Source: OECD (2016)[53]

What are the key elements of such an eco-system. First, for communication to occur there must be networks with sufficient capacity. The communicating needs for IOT devices can be very different. Some may require great speed and volume using national networks while others may use local spectrum for devices in close proximity and that too very infrequently.

[53] The Internet of Things: Seizing the Benefits and Addressing the Challenges, 2016

Figure 3: Relationship between technology and device cost

Source: Nokia white paper on IOT connectivity – understanding the options and choices[54]

The interaction between networks and uses are shown in Figure 2 and 3. The second requirement is standards. For the millions of devices that should be in use in the future it would be useful to have a situation where all these types of devices can interact with each other and developers of devices know in advance the technological specifications that would allow them to do so. It is also important that India participates in the process of standard setting keeping our priorities in mind. The Telecom Standards Development Society-India (TSDSI) has joined seven other standard setting organizations to form the oneM2M partnership. Other organizations such as the International Telecommunications Union (ITU) and 3GPP[55] are also involved in developing standards. There are a number of other issues which are relevant. The most important are to find adequate spectrum, privacy issues, numbering and deployment of IPv6. For devices to communicate they should have numbers like we have phone numbers. There should be some consistency in numbering. We are also running out of internet addresses and deployment of the

[54] https://onestore.nokia.com/asset/201050/Nokia_IoT_Connectivity_White_Paper_EN.pdf

[55] 3rd Generation Partnership Project

Internet Protocol version 6 (IPv6) is necessary. Finally, it should be noted that even though we discuss 5G in a separate section advances in 5G and IOT are inextricably linked.

3.2 Cloud and Fog Computing

At a simple level cloud computing refers to shifting of storage of data and software from devices and storing them on servers accessible by the internet. Desk top computers could be made much smaller if all documents, files and software could be stored elsewhere. This is of even greater importance for tablets and mobile phones. Given the importance of battery life and large screens it leaves little room for storage. This led to the development of mobile could computing (MCC) which has been defined as "an infrastructure where both the data storage and data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smartphone users but a much broader range of mobile subscribers."

A natural progression from MCC is Fog Computing or mobile edge computing (MEC).[56] For IOT to run smoothly and quickly computing has to be done close to the device. However, it cannot be done in the device which would add to the cost of devices and duplicate resources. So, cloud computing has to be moved to the edge of the devices. The idea is not to expand the cloud but to form a virtual network with the help of new technologies such as Network Function Virtualization (NFV), Software Defined Networks (SDN) and HetNets.[57] [58]

3.3 Towards 5G

The promise of IOT and MEC cannot be achieved without 5G. It is possible to deploy IOT and MEC with 4G, but the revolution promised cannot happen unless we have super high speeds and ultra-low latency. For that we need a generational change in mobile technology. There are two views on what constitutes 5G. The first sees it as a consolidation and combination of existing

[56] There are other names such as MiniCloud, Cloudlet and Mobile Edge Cloud depending on who develops the technology.

[57] https://www.openfogconsortium.org/resources/#definition-of-fog-computing

[58] https://www.ijsr.net/archive/v5i5/NOV163418.pdf

technologies that remove obstacles of connection and coverage. Different generations of technology (1G, 2G etc.) and different types of technology (4G, Wi-Fi, WiMAX etc.) would be able to communicate with each other seamlessly. The second view sees it as a generational change in technology to achieve 1 Gbps speed and latency of lower than 1ms.

As with any technology standard setting is important but with 5G no standards have been set as yet. GSMA reports that the industry has identified a set of eight requirements. They are

- 1-10Gbps connections to end points in the field (i.e. not theoretical maximum)
- 1 millisecond end-to-end round-trip delay (latency)
- 1000x bandwidth per unit area
- 10-100x number of connected devices
- (Perception of) 99.999% availability
- (Perception of) 100% coverage
- 90% reduction in network energy usage
- Up to ten-year battery life for low power, machine-type devices

The ITU has also been working on the relationship between the international mobile telecommunications system and 5G. It started work on IMT for 2020 and beyond in 2012 and is expected to come out with its own set of specifications in 2019.

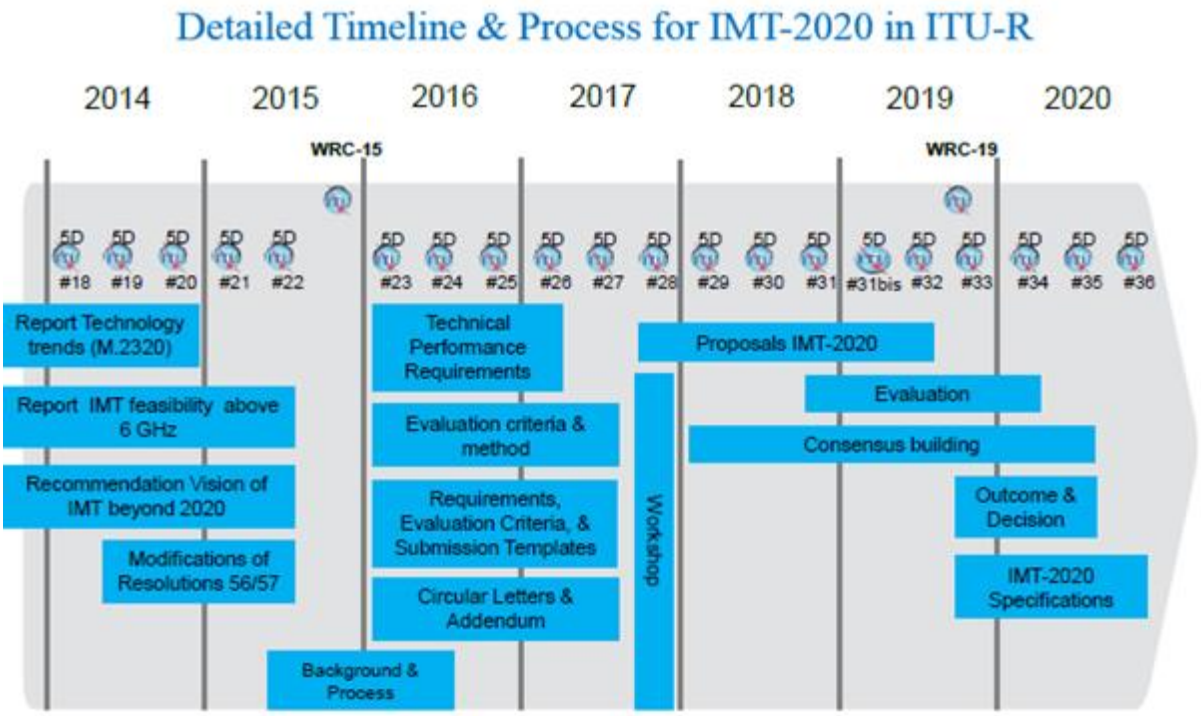

Figure 4: ITU-R Detailed Timeline set by ITU for 5G with group 5D meeting numbers

Source: ITU-R, "IMT for 2020 and beyond"[59]

[59] https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx

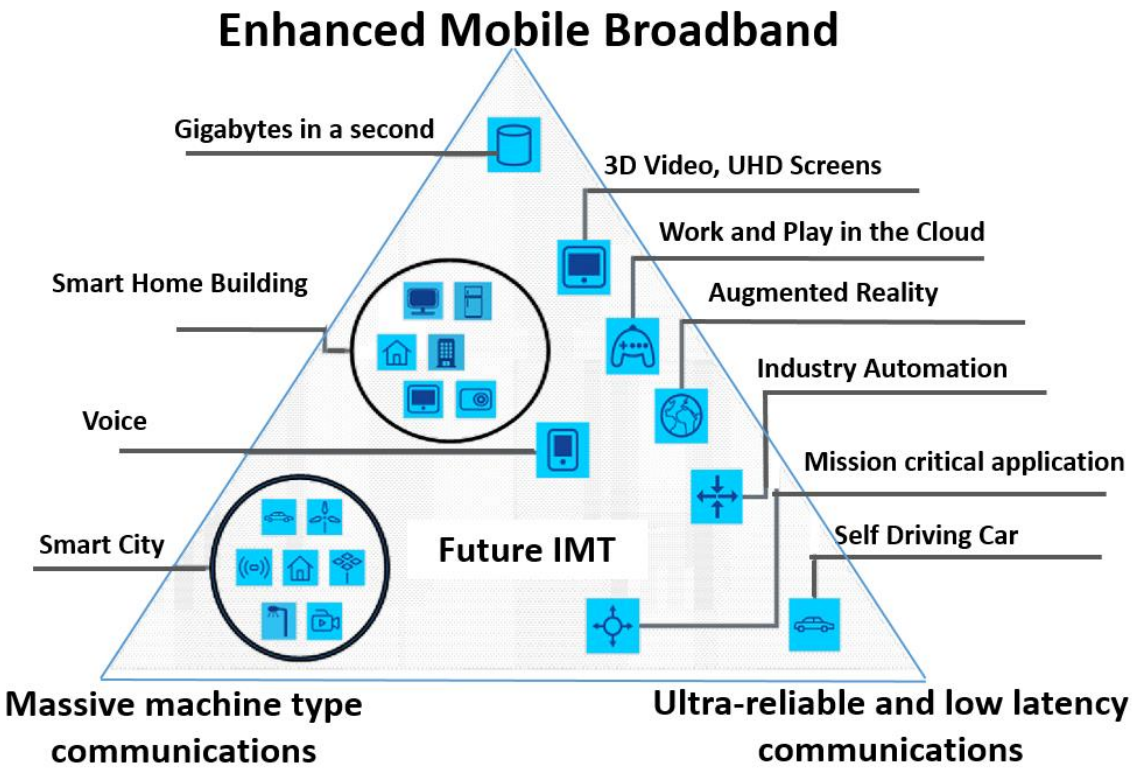

Figure-5 Usage Scenarios for IMT 2020 and beyond

Source: ITU-R, IMT[60]

One would be curious about the kind of uses that IOT, 5G and cloud computing could be put to. Some of these are shown in Figure ###. We should mention a couple of problems. The first is that of spectrum. The focus has been on higher frequencies, between 6 GHz and 300 GHz. However, it would be difficult to use standard technology at such high frequencies. Researchers have focussed on two alternative technologies, beam-forming and multiple- input-multiple output (MIMO). Beam forming can be costly to deploy and MIMO has interference problems. The second is that of cost. Implementing 5G would require overhauling a lot of infrastructure including towers. Whole new networks would have to be built and content and computing would have to be very close to the customer

[60] https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf

3.4 Big Data and Analytics

The omnipresence of data and the digital world means that virtually every search is a mouse-click away. Whether one is seeking their favourite writer's latest release or one is looking for the latest news headlines, all our search nowadays starts with a search engine, which almost always is Google. Every time we use our smartphones, laptops or any intelligent connected device we generate data. Retailers have for long tried to make intelligent interpretations of potential customer requirements from their ongoing purchase behaviour. The US-based retailer Target sending coupons for maternity shopping to a teenage high school girl is a classic text book example. Target's celebrated statistician Andrew Pole had identified a set of 25 products that collectively indicated with high level of accuracy the pregnancy of a woman.[61]

Thus, generating data and making intelligent interpretations about human behaviour is not a new phenomenon. What makes the current situation exceptional is the rate at which we generate data and the power of intelligent and connected devices to make valuable interpretations from this data. With the advent of internet of things and 5G, life is expected to be ever more connected and convenient, but it will also raise tremendous privacy issues. This incredible amount of data (Volume) coming from distinct sources (Variety) at a remarkable pace (Velocity) requires intelligent technologies and high levels of artificial intelligence to make meaningful interpretations (in other words generate Value).[62]

[61] Business Insider, Gus Lubin, The Incredible Story of how Target Exposed a Teen Girl's Pregnancy, dated 16 February 2012 available at http://www.businessinsider.com/the-incredible-story-of-how-target-exposed-a-teen-girls-pregnancy-2012-2?IR=T ; Kashmir Hill, How Target Figured Out a Teen Girl was Pregnant Before her Father did, dated 16 February 2012, available at https://www.forbes.com/sites/kashmirhill/2012/02/16/how-target-figured-out-a-teen-girl-was-pregnant-before-her-father-did/#351a3ba96668.

[62] A De Mauro, M Greco and M Grimaldi, *A Formal Definition of Big Data Based on its Essential Features,* Library Review 65(3) 2016, pgs 122-135; Viktor Mayer-Schönberger and Kenneth Cukier, Big Data: A Revolution that will Transform how we Live, Work and Think (John Murray: Hachette UK 2013.

The data value chain comprises of the following three steps – data collection, data storage and cloud computing & finally, data analytics and use.[63] Data collection, though very valuable, nonetheless in itself is not the only bottleneck in the value chain. It is the ability to make meaningful interpretations about consumer behaviour and purchase decisions through intelligent, algorithm-based devices that makes it a treasured resource.[64]

Moreover, considering the special nature of the markets –that is usually multi-sided platforms – it is extremely important to appreciate the special characteristics of these platforms to assess the competition and innovation debate with respect to big data. These markets are characterised by strong network effects – both direct as well as indirect - which means that competition is often for the markets, rather than in the markets and there, generally is a tendency for the market to tip in favour of one or fewer players.[65] The multi-sided nature also facilitates leveraging dominance from one market to another. Multi-sided platforms (MSPs) may be defined as a market where one or more platforms facilitate two (or more) sides to interact with one another through a suitable pricing strategy for each side.[66] Moreover, there tends to exist a 'feedback loop' between the number of users, amount of data and the quality of services. This means that more users and more frequent searches generate extensive data and this in turn helps the platform (such as Google and Amazon) offer better recommendations to the users. On account of this, the cost of data collection is higher

[63] Marc Bourreau, Alexandre de Streel and Inge Graef, *Project Report dated 16 February 2017 : Big Data and Competition Policy : Market Power, personalised pricing and advertising*, Centre on Regulation in Europe, pgs 11-14.

[64] Viktor Mayer-Schönberger and Kenneth Cukier, Big Data: A Revolution that will Transform how we Live, Work and Think (John Murray: Hachette UK 2013) 74 ff.

[65] Monopolkommission, 'Wettbewerbspolitik: Herausforderung digitale Märkte' Sondergutachten 68 der Monopolkommission gemäβ §§ Abs. 1 Satz 4 GWB (Bonn/Berlin 1 June 2015) <http://www.monopolkommission.de/index.php/de/homepage/84-pressemitteilungen/286-wettbewerbspolitik-herausforderung-digitale-maerkte> accessed 05th December 2017.

[66] Rochet and Tirole, *Two-Sided Markets: A Progress Report'*, 37(3) The RAND Journal of Economics 645 (2006) at page 646.

for a new entrant then the incumbent platform and thus, may constitute a significant barrier to market entry.[67]

Dealing with the first challenge that is considering the enduring dominance and tipping nature of multi-sided platforms, barriers to market entry for new potential entrants are particularly high. An archetypal example of this is the market for search engines wherein Google invariably emerges as the undisputed search leader. So much so, that today we no more seek information on the internet. Instead we 'Google' information! In other words, the indispensability of the search engine has re-defined how we seek information. This brings two challenges forefront – first, the potential entry of new players in the market and second, interestingly, a non-competition, non-innovation concern – that is the impact of big data on democracy

5. Policy Issues

5.1 Privacy

Search engines are well-aware of what we are reading, YouTube knows what we are watching, Uber knows who all we visited, and the connected devices and Amazon may soon be aware how many bottles of milk and slices of cheese remain in our refrigerator and when do we likely need a re-fill. In a connected world, 'privacy' is a big victim.

It is interesting to add though that the discussion on privacy is not as recent as one may think. In fact, the discussion on privacy goes to the very origins of a civilized society. Arthshastra, for instance, talks about the design of homes and suggests that to respect the private space of the residents, windows and doors should not open to the neighbours.[68] Aristotle too referred to the aspects of life – 'polis' and 'oikos' that is the public sphere and the personal sphere respectively.

What makes 'privacy' such an important topic for discussion is increasing availability of big data and related algorithms and technological tools to make valuable deductions about human

[67] Ariel Ezrachi and Maurice E Stucke, *Virtual Competition: The Promise and the Perils of Algorithm-Driven Economy*, Harvard University Press (2016).

[68] Ashna Ashesh and Bhairav Acharya, Locating the Constructs of Privacy within Classical Hindu Law (2014)

behaviour from them. In other words, we no longer are in control as to how much information we want to share about ourselves and in addition there is the added possibility of commercializing this information. To further complicate the things, the devices are talking to and learning from each other. As an example, if I am a regular reader of each and every work of a particular author on Kindle, Amazon knows that I will probably like her forthcoming release too and that it may be potentially profitable to get the rights for his upcoming work even at a premium (provided that there is a substantial critical mass of the population that is willing to purchase her works).

The debate on big data and privacy merits attention as regards the public sector too. The public sector, just as private enterprises can be a very rich source of data. Aadhar, the mandatory biometric 16-digit unique identification number, today has literally all the information about us – from bank accounts, our mobile number and residential address and personal family details. Privacy breach and leakage of Aadhar data, made the scheme controversial.[69] In re Puttaswamy[70], dealing with issue, the Supreme Court of India recently stated that the right to privacy though a fundamental right is a qualified one that needs to be weighed against various benefits such as financial inclusion that the scheme may bring to the citizens of the country. The Apex Court also urged the government authorities to take sufficient precautionary measures to ensure the privacy of citizens. 'Right to privacy' was clearly identified as an integral part of Article 21 of the Constitution 'Right to life and personal liberty', the latter undeniably being the soul and spirit of the Indian Constitution.

5.2 Net Neutrality

There has been considerable furore around the world and in India about net neutrality. In India, the controversy emanated from the Facebook-Reliance initiative to introduce free websites under the title Internet.org. The idea was that certain websites could be accessed free of cost as they would qualify for zero ratings. It was argued that internet penetration in India is low since the cost

[69] Ananthkrishan G, 'In Supreme Court, Centre admits Aadhaar data leak, critics cite 'civil liberties' ', dated 4 May 2017, available at http://indianexpress.com/article/india/govt-admits-aadhaar-data-leak-critics-cite-civil-liberties-4639819/

[70] Justice K S Puttaswamy (Retd.) v. Union of India and Ors., Supreme Court of India, WP (Civil) No 494/2016

of access, usually through mobile phones, is expensive. If the owners of websites could pay for the cost of access, then more people would have access. This would have violated the concept of net neutrality and the TRAI issued recommendations affirming net neutrality in November 2017 prohibiting "discrimination in Internet access based on the content being accessed, the protocols being used, or the user equipment being deployed."[71] The latest salvo in the net neutrality war comes from US, where the Federal Communications Commission (FCC) has overturned its earlier rule on net neutrality that disallowed discrimination.[72]

Net neutrality is a difficult concept to comprehend though it seems simple at first glance (Wu 2003). For us the simple definition given above will suffice. The arguments in favour of net neutrality is that open access to the internet is necessary for budding entrepreneurs who would otherwise be shut out of access to their customers. There is also an egalitarian angle that asserts that everyone should have equal access and harks back to the initial development of the Internet. It is seen as a somewhat anarchical space where everybody was equal, and all manners of opinion could be freely expressed. No one seems to oppose this principle. Instead the argument is that the internet will remain open without net neutrality being imposed, through the forces of competition. Others worry that stipulating net neutrality might harm innovation. Thus, the internet needs to remain free and open without any regulations. In a strange way both sets of arguments sound the same.

6. Recommendations

The TRAI has issued a consultation paper for the National Telecom Policy 2018. The last National Telecom Policy was in 2012 and can be found on the Ministry of Electronics and Information Technology's website[73]. Earlier the ministry was a part of the ministry of communications but now it is a separate ministry. There is a Ministry of Information and Broadcasting which should also be involved in the National Telecom Policy as should the Ministry of Science and Technology. In a

[71] http://trai.gov.in/sites/default/files/PR_No.100of2017.pdf

[72] The exact ruling is more complex than what we have stated here.
https://www.nytimes.com/2017/12/14/technology/net-neutrality-repeal-vote.html

[73] http://meity.gov.in/writereaddata/files/National%20Telecom%20Policy%20(2012)%20(480%20KB).pdf

world of convergence, the government remains diverged and is diverging even more. The government should consider a working group of different ministries or have a separate ministry for ICT coordination. All government bodies are involved in producing ICT products: be it interactive websites of ministries to municipalities to apps developed by the TRAI. It would be useful if all such information were to be collated for easy access. Greater coordination is required among the different parts of the government. Otherwise at best, efforts will be duplicated as information is not available. At worst, policy making will be incoherent.

We should also calibrate our efforts to catch up with advanced economies. While the promise of 5G and IOT are alluring we should not forget that we haven't rolled out 4G in most parts of the country. We should not accentuate the digital divide that already exists any further. This does not imply that we remain unconcerned about technological developments. It is important to participate in standard setting and being aware of technological developments.

As regards privacy, in addition to the recent judicial pronouncement by the highest court of the country in Aadhar as discussed above, legislative action is the most pressing need of the hour. The most pressing amongst these is the need to have a privacy and data protection law in the country. The country has to date no data protection legislation or any specific privacy law. The Privacy Bill 2011, and the valuable recommendations of the Shah Commission, first presented in 2012, is yet to see the light of the day. Shah Commission's report in addition, though very valuable at the time, too may have missed the bus as many of the issues that big data has brought forefront in last three-four years. The report was written at a time, when the challenges from big data were just emerging. Add to this the complexities that the connected devices may introduce to the world of big data.

It is imperative to add that considering the dynamic nature of the information age, any legislation that is likely to be the key to preserve not only in the process of competition but also uphold the constitutional values of right to life (right to privacy being read as a part of it), needs to be forward looking and for a meaningful and constructive debate on the subject must pursue an inter-disciplinary approach using insights from law, economics and information scientists.

7. Conclusion

This paper has attempted to discuss all relevant issues that face Indian telecommunications. This is too vast a subject for us to able to do justice within the space of a paper. Undoubtedly, readers would feel that more issues should have been included and that some issues have been dealt with superficially. We hope to continue our engagement with the exiting and sometimes frustrating world of telecommunication in India.

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