5G AND BEYOND:
FORMULATING A REGULATORY RESPONSE

Report

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5G and Beyond:
Formulating a Regulatory Response

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<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3. A new licensing regime</td>
<td>31</td>
</tr>
<tr>
<td>3.4. Migration Plan</td>
<td>33</td>
</tr>
<tr>
<td>3.5. Revenue Estimates</td>
<td>34</td>
</tr>
<tr>
<td>3.6. Conclusions</td>
<td>35</td>
</tr>
<tr>
<td>References</td>
<td>36</td>
</tr>
<tr>
<td>Chapter 4. Spectrum Regulation</td>
<td>39</td>
</tr>
<tr>
<td>Abstract</td>
<td>39</td>
</tr>
<tr>
<td>4.1. Introduction</td>
<td>39</td>
</tr>
<tr>
<td>4.2. Method of spectrum allocation in India</td>
<td>40</td>
</tr>
<tr>
<td>4.3. History of Spectrum Prices in India</td>
<td>42</td>
</tr>
<tr>
<td>4.4. Analysis of variables that affect Spectrum Price</td>
<td>43</td>
</tr>
<tr>
<td>4.5. Role of unlicensed spectrum: Wi-Fi as Complement or Substitute</td>
<td>44</td>
</tr>
<tr>
<td>4.5.1. Wi-Fi Networks</td>
<td>44</td>
</tr>
<tr>
<td>4.5.2. Wi-Fi 6 and Beyond</td>
<td>46</td>
</tr>
<tr>
<td>4.5.3. The unique case of 60 GHz band</td>
<td>47</td>
</tr>
<tr>
<td>4.5.4. The co-existence of 5G NR-U and IEEE 802.11 networks</td>
<td>47</td>
</tr>
<tr>
<td>4.6. Coexistence in the C-Band</td>
<td>48</td>
</tr>
<tr>
<td>4.6.1. The CBRS Band in the US and SAA</td>
<td>48</td>
</tr>
<tr>
<td>4.7. Spectrum for Satellite Networks</td>
<td>49</td>
</tr>
<tr>
<td>4.8. New approaches to effective spectrum management</td>
<td>51</td>
</tr>
<tr>
<td>4.8.1. Light licensing and flexible spectrum regulation</td>
<td>51</td>
</tr>
<tr>
<td>4.8.2. Flexible Spectrum Management: from static to dynamic approaches</td>
<td>52</td>
</tr>
<tr>
<td>4.8.3. Dynamic Spectrum Sharing</td>
<td>54</td>
</tr>
<tr>
<td>4.9. Conclusions</td>
<td>54</td>
</tr>
<tr>
<td>References</td>
<td>55</td>
</tr>
<tr>
<td>Chapter 5. From Net Neutrality to Digital Neutrality</td>
<td>58</td>
</tr>
<tr>
<td>Abstract</td>
<td>58</td>
</tr>
<tr>
<td>5.1. Introduction: What is Net Neutrality?</td>
<td>58</td>
</tr>
<tr>
<td>5.2. Net Neutrality in India</td>
<td>60</td>
</tr>
<tr>
<td>5.3. New Value Chain</td>
<td>61</td>
</tr>
<tr>
<td>5.3. Changing Commercial and Technical Realities</td>
<td>63</td>
</tr>
<tr>
<td>5.3.1. Increasing amounts of data, and increasing varieties of applications</td>
<td>63</td>
</tr>
<tr>
<td>5.3.2. Increased power of CAPs</td>
<td>64</td>
</tr>
<tr>
<td>5.4. Potential Synergies from Closer Collaboration Between CAPs and TISPs</td>
<td>65</td>
</tr>
<tr>
<td>5.4.1. Network slicing and its effects on Net Neutrality</td>
<td>66</td>
</tr>
<tr>
<td>5.5. Net Neutrality Policy Directives in a 5G World</td>
<td>67</td>
</tr>
</tbody>
</table>
5.6. Digital Neutrality................................................................................................................ 68
5.7. Conclusions ...................................................................................................................... 68
References.................................................................................................................................. 69
Chapter 6. Interconnection and Data Portability Regulation................................................... 72
Abstract .................................................................................................................................... 72
6.1. Taxonomy of Interconnection charges ............................................................................. 72
6.2. Termination Charges ........................................................................................................ 73
6.3. Interconnect Congestion................................................................................................... 75
6.4. Interconnection charges for IP based calls ...................................................................... 76
6.4.1. Internet telephony calls terminating on Carrier Network ........................................... 76
6.4.2. International Internet telephony calls terminating on local Carrier Network .......... 77
6.4.3. Recent regulation on interconnection of Internet Telephony .................................... 79
6.5. Interconnection between OTT Communication Apps ...................................................... 79
6.5.1. Evolving communication technologies for Internetworking .................................... 80
6.6. Access to Emergency Services ....................................................................................... 81
6.7. Number and Data Portability .......................................................................................... 82
6.7.1. Number portability ...................................................................................................... 82
6.7.2. Data portability ........................................................................................................... 82
6.8. Conclusions ...................................................................................................................... 83
References.................................................................................................................................. 84
Chapter 7. Universal Service Policy ......................................................................................... 87
7.1. Introduction ....................................................................................................................... 87
7.2. Universal Services Levy ................................................................................................... 87
7.3. Uses of the Universal Service Levy .................................................................................. 87
7.4. Theoretical Issues: What to Build .................................................................................... 89
7.4.1. Good 4G: A Consumption Norm ................................................................................ 90
7.4.2. Fixed line infrastructure for 5G in urban and semi-urban areas: A System Requirement ......................................................................................................................... 91
7.5. Theoretical Issues: Who to Charge .................................................................................. 91
7.6. The Twin Engines of Digital India: Infrastructure supply & Demand ............................... 92
7.7. Conclusion ........................................................................................................................ 93
References.................................................................................................................................. 93
Chapter 8. Summary of Recommendations ............................................................................ 95
8.1. Technologies ..................................................................................................................... 95
8.2. Integrated Sphere of Competition .................................................................................... 95
8.3. New Licensing Framework .............................................................................................. 95
List of Tables

Table 2-1. Complementarity OTT services ................................................................. 16
Table 2-2. Substitutability of MNO and OTT services ................................................ 17
Table 3-1. Functional Separation and Convergence in Infrastructure ....................... 28
Table 3-2. Details of the Licensing Framework ......................................................... 32
Table 3-3. Regulatory Fees as per the Current Regime .............................................. 34
Table 3-4. Regulatory Fees as per the Proposed Regime ........................................... 34
Table 4-1. Summary Statistics of Spectrum Auctions held in India ......................... 43
Table 4-2. Analysis of the determinants of spectrum prices in India ......................... 44
Table 4-3. Summary of Wi-Fi Technologies ............................................................... 45
Table 4-4. Examples of Light Licensing Sharing Approaches .................................... 52
Table 5-1. Dimensions of Net Neutrality ................................................................. 59
Table 5-2. Type of charges in the Internet value chain ............................................. 62
Table 6-1. Revision of Termination Charges by TRAI ............................................. 75
Table 6-2. Existing regulation on Interconnection and emergency services ............. 81
Table 6-3. Proposed regulation on Interconnection and emergency services ............ 84
Table I-1. Summary of Stakeholder Interviews ....................................................... 100
Table I-2. Telecom versus OTT Communication Services ....................................... 104
Table I-3. Spectrum Carve-outs or not for CNPNs .................................................. 108
Table I-4. Licensed versus Unlicensed Spectrum ...................................................... 112
Table III-1. Variation in Reserve and Winning bid prices of spectrum in India ........ 120
Table III-2. Variation in available and allocated spectrum in India ......................... 122

List of Figures

Figure 1-1. Network Slicing ...................................................................................... 11
Figure 3-1. Existing License Structure ...................................................................... 26
Figure 3-2. The Layered approach to Digital Communications ................................. 29
Figure 4-1. Taxonomy of Radio Spectrum ............................................................... 40
Figure 5-1. The Two-Sided Platform Model of TISP ............................................... 58
Figure 5-2. The Internet Value Chain ....................................................................... 62
Figure 5-3. Global IP traffic developments (fixed and mobile) ................................. 63
Figure 5-4. Mobile traffic by applications .............................................................. 64
Figure 6-1. Call flow across LSA within a country .................................................. 72
Figure 6-2. Call flow of an International call .......................................................... 73
Figure 6-3. Schematic diagram of IP device <-> PSTN/PLMN device call ............... 77
Figure 6-4. Schematic diagram of International Internet Telephony call flow .......... 78
Figure 7-1. Growth of USOF in India over the years (Fund status in Rs. Cr.) ......... 88
Figure 7-2. Stream wise distribution of USOF ....................................................... 88
Glossary

3GPP: The 3rd Generation Partnership Project (3GPP) is a collaborative project between a group of telecommunications associations with the initial goal of developing globally applicable specifications for third (3G) and future generation mobile systems.

5G: Fifth Generation Network: Fifth-generation wireless (5G) is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks. The 3GPP standards committee started the migration from 4G LTE to next generation 5G in 3GPP Release 14 in 2016. The New Radio (5G NR) requirements for 5G communication networks were defined in 3GPP Release 15 that started in 2017 and concluded in 2018.

AGR: Adjusted Gross Revenue—The gross revenue accruing to the telecom licensees by way of operations of the cellular mobile service as per their license conditions.

ASP: Access Service Provider who is licensed/authorized to provide telecommunication access services including wireline and mobile services.

CAP: Content and Application Providers who provide content and application to the end users typically through landline or mobile network services.

CBRS: Citizens Broadband Radio Service is a mobile service operating mainly in the U.S. in Federal Communications Commission (FCC) authorized band of 3550-3650 MHz (3.5 GHz C-Band) currently used for military and satellite communication in shared use mode.

CCB: Communications Convergence Bill drafted in 2020; however not enacted in the parliament; envisioned “triple play” including the convergence of voice telephony, Internet connectivity and video services.

CDN: Content Distribution Network is a system of distributed servers (network) that deliver pages and other Web content to a user, based on the geographic locations of the user, the origin of the webpage and the content delivery server.

CNPN: Captive Non Public Networks that are deployed mainly for enterprise use, either by MNOs or non-MNOs using spectrum that is exclusively allocated or otherwise. The CNPNs by definition shall not be connected to the public PSTN/PLMN or the Internet.

DoT: Department of Telecommunications, unit of the Ministry of Communications of the Government of India, with a vision to provide secure, reliable affordable and high quality converged telecommunication services anytime, anywhere for an accelerated inclusive socio-economic development.

eMBB: Enhanced mobile broadband (eMBB) is, in simple terms, an extension of services first enabled by 4G LTE networks that allows for a high data rate across a wide coverage area.

FCC: The Federal Communications Commission (FCC) is an independent agency of the United States federal government that regulates communications by radio, television, wire, satellite, and cable across the United States.

ISP: Internet Service Provider who is licensed/authorized to provide access to the public Internet.

ITU: The International Telecommunication Union (ITU) is an agency of the United Nations (UN) whose purpose is to coordinate telecommunication operations and services throughout the world.

IoT: The term IoT, or Internet of Things, refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves.
mMTC: massive Machine Type Communication, supported in 5G, that can connect more than 1 million devices per square kilometer and provide support for Internet of Things, vehicle-to-vehicle communication, Smart Cities wherein sensors and machines communicate with each other in a semi-automated way.

MNO: Mobile Network Operators who are licensed to provide cellular mobile communication services.

MVNO: Mobile Virtual Network Operator - A licensed mobile service provider who normally leases/rents spectrum and other associated facilities from an MNO to provide mobile communications and Internet services.

NFAP: National Frequency Allocation Plan prepared by the Wireless Planning and Coordination Wing of the Department of Telecommunications periodically to designate different spectrum bands for different usages

NFV: Network Function Virtualization: NFV is a network architecture which aims to accelerate service deployment for network operators and reduce cost by separating functions like firewall or encryption from dedicated hardware and moving them to virtual servers, collapsing various functions into a physical server, which ultimately reduces overall cost.

O-RAN: Open Radio Access Network is a concept based on interoperability and standardization of RAN elements including a unified interconnection standard for white-box hardware and open source software elements from different vendors.

OTT: Over The Top is an Information and Communication Technology service provided over the Internet, untethered from the underling network. Examples include instant messaging, voice over the Internet protocol.

PLMN: Public Land Mobile Network - The mobile telecommunication network that provides voice/data services.

PSTN: Public Switched Telephone Network - The telecommunication network typically with wire-line access, that provides voice/data services.

QoS: Quality of service (QoS) is the use of mechanisms or technologies that work on a network to control traffic and ensure the performance of critical applications with limited network capacity.

SDN: Software Defined Network: SDN is a networking architecture which aims to improve overall network performance and make networks agile and flexible by enabling a dynamic and programmatically efficient network configuration.

TISP: Telecom and Internet Service Provider: Typically a licensed entity that provides traditional telephony and Internet access service.

TRAI: The Telecom Regulatory Authority of India (TRAI) is a regulatory body set up by the Government of India under section 3 of the Telecom Regulatory Authority of India Act, 1997. It is the regulator of the telecommunications sector in India.

UL: Unified License awarded to service providers with an accompanying authorization for providing services such as access service, Internet service, Satellite service, Virtual Network Operations services and so on.

URLLC: Ultra Reliable Low Latency Communication (URLLC), support in 5G that guarantees less than 1 millisecond latency to provide services such as automated robotic surgery, self-driving cars, real-time fleet management that require extremely reliable instant communication.

USO: Universal Service Obligation - The telecom policy that enables the availability of telecommunication services in a non-discriminatory manner to all citizens of the country. Normally funded by USO Fund, collected through USO Levy (UASL) collected from the telecom operators.
**VNO**: Virtual Network Operator - A licensed telecom operator who normally leases/rents spectrum and other associated facilities to provide telecommunications and Internet services.

**VoIP**: Voice Over Internet Protocol - Process of sending voice traffic in the form of packets over IP networks. VoIP digitizes analog voice, compresses it, packetizes and sends it to the receiver.

**Wi-Fi**: Wireless Fidelity - Local area wireless networks based on IEEE 802.11 b/g/n standards operating in the license free Industrial Medical and Scientific (ISM) radio frequency bands of 2.4 GHz and 5 GHz. Internet services using this technology is normally provided by the ISPs.

**WiGig**: WiGig, alternatively known as 60GHz Wi-Fi, refers to a set of 60 GHz wireless network protocols. It includes the current IEEE 802.11ad standard and also the upcoming IEEE 802.11ay standard. The WiGig specification allows devices to communicate without wires at multi-gigabit speeds.

**XMPP**: eXtensible Messaging and Presence Protocol (XMPP), which is an open standard for instant messaging, presence, multi-party chat, voice and video calls, collaboration, lightweight middleware, content syndication, and generalized routing of eXtensible Markup Language (XML) data.
Executive Summary

5G networks are being rolled out across the world, and as per the (Global System for Mobile Communications) GSM Association, 198 networks have been deployed in 79 countries. 5G is estimated to account for as many as 1.2 billion connections by 2025, covering almost 26 percent of global connections worldwide. Mobile Network Operators (MNOs) worldwide, are likely to invest over $600 billion between 2022 and 2025 for deploying 5G networks. Soon after the auction of 5G spectrum, Indian MNOs launched their 5G service in October 2022.

Benefits of 5G networks and services will accrue to industry by providing massive machine type communication (mMTC) and realizing the vision of Industry 4.0. On the consumer side, 5G users are expected to provide a fillip to video/music streaming, consumer IoT applications such as smart homes, gaming and other entertainment services, all enabled by enhanced Mobile Broadband (eMBB). Other changes in applications include deployment of Captive Non-Public Networks (CNPNs) for enterprise use. Along with new use cases, new business models are also being forged between network equipment manufacturers (NEMs), MNOs and cloud service providers. Spectrum management techniques are also adapting to these changes with the introduction of tiered spectrum access, spectrum sensing, etc. It is in this context that our report provides a review of various regulatory issues impacting the telecom sector, including licensing, spectrum management, interconnection, universal service and data governance, to recommend guidelines most suited to this evolving industry scenario.

The technological and business possibilities of 5G technologies and beyond, demand a fundamental review of our existing regulatory paradigms. The telecom regulatory landscape has a chequered history, oscillating between a strict “command and control” approach to unconstrained flexible, on different regulatory issues. However, having achieved near a billion connected to mobile networks and services, India, as the second largest telecom market in the world, next only to China, has the opportunity to seed new approaches to telecom regulations, breaking away from the shackles of the past.

Given the wide-ranging impact expected from 5G, any regulatory formulation needs to undertake wide-ranging consultation with technologists, telecom operators, software vendors, lawyers, and industry leaders. Towards this, we have used a combination of methods in this study including: (i) exhaustive stakeholder consultation (see Appendix-I for details of stakeholder responses); (ii) survey of existing literature on regulations specific to 5G and (iii) analysis of regulations across different countries to provide international benchmarks (see Appendix-II for a summary of international best practices). We have taken into account the critical issues in regulation including: (i) Telecom and Internet Value Chain; (ii) Extant Regulation and the Future (iii) Antitrust and Competition; (iv) Spectrum Management; (v): Interconnection and interoperability; (vi) Universal Service and (vii) Net Neutrality.

Our recommendations rest on two central ideas: first, the functional separation of infrastructure and services; second, the creation of a network integrator that brings together various entities that form a part of the infrastructure layer, and is also the entity licensed to hold spectrum. These two ideas flow from the need to incentivize competition and promote innovation in the services layer; and to facilitate investment and the growing modularization of the infrastructure layer. These ideas have a long tradition in the conversation on regulatory frameworks in Indian telecommunications starting from the Communications Convergence Bill of 2001. However,
they have eluded committed acceptance. Not adopting these ideas at this stage will delay investment, stifle innovation, inhibit the unbundling of the infrastructure layer, promote industry concentration, and detract from the dream of broadband for all. Finally, to address the emerging landscape of co-opetition between internet and telecommunications companies, we also recommend an integrated approach for regulation of the two industries. We espouse the approach of ‘diagonal equity’ to rationalize the treatment of the two industries while not ignoring their important differences.

It is important to note that our recommendations are not meant to be mandates but ‘nudges’ that would be operationalized through tax and other incentives. A wide spectrum of industry configurations is possible within our regulatory framework ranging from the current vertically integrated structures to completely unbundled formations and everything in between. The precise configuration would be dynamically determined via the unfettered choices of industry participants.

Since global regulatory frameworks are still at nascent stages of transformation, India has an opportunity to be a pathbreaker in formulating an optimal regulatory response to the opportunities presented by technologies on the anvil. We should aim to go beyond our legacy as well as current global best practices to pave the path to the future. We hope this report conceived of by the ICRIER and Vodafone Idea Centre for Telecom (InViCT) will contribute in this endeavor.
Chapter 1. Transformed technological landscape of digital services

Abstract
This chapter elaborates upon some critical technological changes in the telecom and digital technologies that have significant competitive and regulatory implications:

1. The modularization of the connectivity value chain.

The development of open radio access networks under which the telecom network is virtualized and modularized is explained, and the possibilities emerging for infrastructure provisioning is explained. The development of a new element of competition between telecom companies and OTTs is outlined while their continuing cooperation is acknowledged. Thus, an Integrated Sphere of Coopetition of Digital Services is coming into being.

There are two trends that we witness in the evolution of 5G and beyond: (i) the technology shift from hardware to software and (ii) the corresponding change in the industry landscape. There are both complementary and substitutable services being offered by the Internet firms (aka Over the Top (OTT) communication providers) akin to those provided by the MNOs. Value appropriation, once the forte of telcos, especially the Mobile Network Operators (MNOs) is being shifted to Content and Application Providers (CAPs), while the direct network effects experienced by the MNOs are being surpassed by both the indirect and cross-side network effects of the CAPs. In this chapter, we indicate these distinct technological and market changes that necessitate a new regulatory paradigm in the 5G world and beyond.

1.1. The modularization of the connectivity value chain

The modularization of the connectivity value chain opens vistas for the entry of new entities in the connectivity value network, and potentially shifts power dynamics in the telecommunications industry.

1.1.1 Technology Modularity and Open Networks

The modularity of technical components started with the advent of the Internet. The Internet protocol itself is a layered architecture that promotes the development of the different layers which are then glued together vertically for end-to-end connectivity. The principle expounded by the Open Systems Interconnect (OSI) model clearly lays down modularity in network architecture. Each layer is modular and depends on the layer below. The communication across the layers are achieved through programming interfaces. Tanenbaum & Wetherall (1996) provide an excellent exposition of the modularity and the logical layers of OSI. Modularity in turn promotes openness as the different modules can be created and developed by various firms or individuals and then can be integrated as a whole.

The computer industry until the 1970s used proprietary closed architecture, thanks to IBM. However, the innovation by Apple created the personal computer (PC) era. With Intel making chips, and Microsoft developing the operating system, the PC industry promoted openness
and created intense competition in the components industry across chips, memory, input/output devices, displays and printers. IBM struggled to transform its mainframe monolithic computer architecture to the federated architecture of the PCs. Though Apple used a closed hardware, software system, the Windows-Intel PCs took the market share from Apple and IBM in the 1980s (Farrell & Weiser, 2003). The software operating system of Microsoft complemented the hardware produced by Intel, resulting in modular hardware and software architectures in the PC industry.

Product architectures are said to be modular if the engineering interfaces defining the ways in which product components interact are standardized. Standardized interfaces allow some variance in the design details of individual product components, leading to "modular innovation" of product components (Argyres & Bigelow, 2010). The result is evident in the innovation witnessed in the semiconductor industry including the development of high performing memory, processors, and display devices. In software, the modularity of components such as operating systems, applications, and middleware has accelerated the development of a competitive component ecosystem. Development of various standards on the specification of the interfaces is a major step towards interoperability of components manufactured by different vendors. The purpose of interface standards is to assure that a system built from “conforming” components originating from different sources will be functional (David & Steinmueller, 1994). Initially, standards defined physical things. Then they evolved in support of the industrial wave to define the physical relationship between things. Later, standards used for information transfer in the information wave defined the virtual relationship between things such as a radio transmitter and a radio receiver (Krechmer, 1996). In telecommunications, the air interface standards for mobile telephony such as CDMA and LTE, set by Standards Setting Organizations (SSOs) such as Third Generation Partnership Project (3GPP) enabled telecom equipment makers and mobile handset firms to build comparable products for the provisioning of mobile telephony and broadband. In the computer industry, the codification standards set by American Standard Code for Information Interchange (ASCII) and Unicode provide for consistent encoding, representation, and handling of text characteristics, including the structuring of the domain name systems used in the Internet. The standards on the Application Programming Interface (APIs) promote compatibility and interworking of different software components built by different vendors and promote vertical separation of the components industry. Hence, in general, the modularity of components and the interoperability between components through standard interfaces create a competitive environment for the component industry.

Similarly, the telecom industry also initially resisted modularity and openness. This was evident in the multi-year long Hush-A-Phone controversy in which AT&T in the U.S. objected to the use of a cup-like device over the phone receiver for limiting background noise. The US FCC agreed with AT&T's decision and directed that such third party devices that affect the integrity of the telecom network should not be used. However, FCC learnt its lesson and subsequently rejected AT&T's efforts to block the use of the "Carterfone", a device that connected a telephone line to a two-way radio, so that people using the radio could gain access to the telephone network and those on the network could communicate with those using radio (Nuechterlein & Weiser, 2005). The above two cases illustrate the monopolistic control exhibited by the incumbent telecom carriers across services and devices. However, with the onset of GSM technology, the development of handset modularity especially of mobile
phones, and the Subscriber Identification Module (SIM) have provided logical and physical separation of handsets and network services.

1.1.2. Open Radio Access Networks

As technologies evolve and markets mature, the need for “light touch regulation” is being proposed in most of the countries. One of the ways by which regulatory monitoring can be minimized is to move towards “open access” as it is paramount to the evolving digital economy (ITU, 2011). Open access is “the possibility for third parties to use an existing network infrastructure”, according to the Best Practice Guidelines for Enabling Open Access, adopted by the 2010 Global Symposium for Regulators.

While there is no single definition of open access, the general principles include non-discriminatory access to physical network infrastructure for provisioning of telecom and associated service. In Europe, for a long time, open access was discussed in the context of public sector participation in building a network infrastructure that is opened up for non-discriminatory access. The proponents of open access argue that it provides a good balance between static and dynamic efficiencies (Kramer & Schnurr, 2014), i.e. efficient allocation of resources given fixed technologies, and efficient allocation of resources for optimizing technological progress.

Definition of open access by Forzati et al. (2010, p. 1) is given below:

“In the open access network model, the roles of the service provider and the network owner are separated, and the service providers get access to the network and the end customers on fair and non-discriminatory conditions.”

The mobile, or cellular/wireless network comprises two domains: the Radio Access Network (RAN) and the Core Network (Core). The RAN provides the last mile between mobile handset and the mobile network. The visible components of the RAN include the antennas that we see on top of nearby mobile towers and Base Stations (BSs). When we make a call or connect to a remote server e.g. to watch a YouTube video, the antenna transmits and receives signals to and from our phones or other hand-held devices. The signal is then digitized in the RAN base station and connected into the network. The Core has many functions. It provides access controls ensuring users are authenticated for the services they are using, it routes telephone calls over the PSTN, it enables operators to charge for calls and data use, and it connects users to the rest of the world via the Internet. It also controls the network by making handovers happen as a user moves from coverage provided by one RAN tower to the next (Nokia, 2021). Broadly, the components in the RAN include (i) Radio Unit (RU); (ii) Distributed Unit (DU); and (iii) Centralized Unit (CU). While the RU contains the critical component for providing the radio interface between mobile station and the network, DU and CU are computational elements that can be embedded in software.

Virtual RAN refers to a radio access network where the virtual elements - software, and storage infrastructure - predominate over traditional radio equipment like transmitters, and antennae. 5G technologies have accelerated the move toward virtualization of the network. This virtualized network is called V-RAN. The V-RAN is critically dependent on cloud
infrastructure for storage and routing. This aspect of 5G architectures is called the Cloud Radio Access Network (C-RAN). The C-RAN fosters efficient network and resource sharing as well as real-time and flexible scheduling in a centralized fashion (Gavrilovska, et al., 2020). The shared infrastructure provides the required scalability in the RAN architecture.

5G technology is also associated with a densification of the network as microwave frequencies are used to provide high bandwidth services with ultra-low latencies. The distance between the end user and the core network is coming down. This leads to the significant increase in the demand for the build out of optic fibre networks.

*The emergence of V-RAN also opens up further possibilities for open architectures and leads to a re-definition of open access: not only do service providers get access to the network and the end customers, on fair and non-discriminatory conditions, but the network itself has an open architecture with standard interfaces that can be provided by a combination of entities.*

Open-RAN (O-RAN) architecture focuses on two fundamental pillars: Openness and Intelligence. Open interfaces are vital to support smaller vendors and operators to swiftly introduce novel services, and enable operators to tailor the network based on their own requirements. Openness also enables multi-vendor V-RAN deployments, resulting in a more competitive and richer ecosystem. Moreover, open-source software and hardware designs can facilitate faster, and more efficient innovation and commercial deployment, while preserving backward compatibility with legacy systems. For this, standardization and interoperability is critical.

A number of entities could combine to provide O-RAN architectures. These include:

1. Telcos
2. Software vendors
3. OTTs
4. Equipment vendors
5. Cloud service providers
6. Fixed line infra providers
7. Tower companies

The key concept of Open RAN is “opening” the protocols and interfaces between these various building blocks (radios, hardware and software) in the RAN. The O-RAN ALLIANCE has defined 11 different interfaces within the RAN for interoperability across devices and vendor systems. The O-RAN, C-RAN and V-RAN basically makes the RAN architecture more flexible, with RU remaining almost the same as in the traditional RAN; however, moving DU and CU away from the RU to software components that can be present at a remote host or on the cloud, thus paving way for a more resilient, reliable and scalable architecture.

### 1.2. Captive Non-Public Networks: A Game Changer

In the pre 5G era, the last mile connectivity, i.e. from the cellular towers and associated BTS to end user devices, were exclusively provided by the MNOs. Even in landline, the Wi-Fi connectivity to wired broadband was provided by the telcos. Large enterprises supplemented
the MNO services by constructing their own campus Wi-Fi networks. Though public Wi-Fi has been in existence since 1980s the commercial deployments of large scale public Wi-Fi including municipal Wi-Fi have not been found viable.

The 5G microcellular deployments have been changing the competition landscape. The 5G technology enables high capacity broadband communication (enhanced Mobile Broadband - eMBB) or Ultra Reliable Low Latency Communication (URLLC) for industry automation, in a contiguous local area. This area could be indoors or include the adjacent outdoors. The network might be private and for use by a single enterprise such as in a factory or on a corporate or university campus, also referred to as Captive Non-Public Networks (CNPNs). These networks can be telco led through options such as network slicing or spectrum leasing or deployed by entities other than MNOs, such as Network Equipment Manufacturers, tower companies, Wi-Fi gear providers to name a few, Examples of direct deployment by Enterprises include the one constructed for Lufthansa Technik by Nokia in Finland; Bosch setting up private 5G networks in about 250 of its locations in partnership with Nokia (Enterprise IoT Insights, 2022); Volkswagon constructing its own “5G island: in its manufacturing plant in Dresden, Germany (Volkswagen, 2022). There are various reasons for enterprises to construct their own private networks including increased security, lower latency and congestion, greater network control, leveraging existing campus infrastructure such as indoor Wi-Fi networks, and so on. Such networks are possible in 5G due to the increased availability of high-performance, low-cost network equipment with software that assists self-configuration (Lehr, et al., 2021). However, due to the increasing complexity of 5G technology and the more demanding factory and industrial use-applications, telcos / MNOs are becoming the preferred deployment partners (either as network providers or delivery partners). As a result, telcos across the globe are forming partnerships with equipment suppliers, specialized network service providers, and systems integrators to provide 5G private network services.

An important aspect in direct deployment by enterprises pertains to the allocation of spectrum to enterprises. The spectrum management policy needs to be carefully planned to avoid the risk of fragmenting the scarce 5G spectrum resources. For example, the failure to achieve contiguous blocks may result in reduced speeds, poorer quality of service and the inability to dynamically reallocate frequencies to accommodate varying traffic patterns on public networks.

1.2.1. Network Slicing

Network slicing refers to partitioning of one physical network into multiple virtual networks, each architected and optimized for a specific application/service. Network slice is a virtual network that’s created on top of a physical network in such a way that it gives the illusion to the slice tenant of operating its own dedicated physical network. This configuration has become an essential component of the overall 5G architectural landscape. Each “slice” or portion of the network can be allocated based on the specific needs of the application, use case or customer (Viav, 2022).The following figure illustrates how network slicing in 5G can be designed to provide to accommodate different types of services such as URLLC and MMTC with varying QoS requirements.
The following are the advantages of network slicing in 5G networks:

1) Network with better performance tailored to all the different types of networks.
2) Easier to scale up or down depending on the number of users and associated requirements.
3) Isolation of networks thereby increasing reliability and security for each slice.
4) Customised network slices for each type of service or businesses.

For example, in China, there are time-sensitive networks for electrical grids and wide-area private networks for mines, which run on network slices. Private networks and network slicing are two very different ways of providing users and subscribers the best possible quality of service while balancing efficiency with security.

The following are potential disadvantages of network slicing (Enea, 2023):

1) Spectrum and Capacity Fragmentation: One potential risk of network slicing is fragmentation. If network slices are not properly managed and coordinated, they can lead to fragmentation of the network, making it harder to manage and optimize network resources. This can result in inefficiencies and poor network performance.
2) Network Security: Another challenge is security. While network slicing can provide enhanced security by isolating traffic between different slices, it can also introduce new security risks if slices are not properly secured. For example, if a security breach occurs in one slice, it could potentially spread to other slices and compromise the entire network. Vulnerable private networks can be used to launch attacks on other devices or networks, including the public network.

3) Investment: In addition, implementing network slicing can be complex and expensive, requiring significant investments in new network infrastructure and technologies. This can be a barrier for some network operators, particularly smaller ones with limited resources.

4) Effect on private networks: Since private networks consume allocated network and spectrum bandwidth, if over allocated, can decrease available bandwidth in the public network. This can impact the QoS of the public network users.

The international deployments of CNPNs is provided in Appendix-III.

1.3. Neutral Hosts

The Neutral Host (NH) is a term that combines two concepts: host and neutrality. The host component signifies an entity that makes a pool of resources accessible to users so that the hosted clients can continue to deliver connectivity services. The `neutrality` component refers to the host's ability to serve diverse clients as a shared platform. The resources made available to each client are governed by a commercial agreement as well as policy-based administration between the NH and the hosted client (Bajracharya, et al., 2022).

These private networks could also be shared for public use either within the campus itself or in adjacent outdoor areas to provide seamless experience to the users. This complementarity of a private network for public use can enable the formation of “neutral hosts”. A neutral host firm provides wholesale infrastructure sharing services through digital platforms to the downstream-markets enabling customers to take advantage of economies of scale and scope of local networks (Lähteenmäki, 2021). Further, the radio network slicing and network function virtualization as part of the 5G network protocols enable the neutral hosts to apportion bandwidth across public and private networks with associated quality of service requirements. This is a paradigm shift from what we have been witnessing prior to 5G. For example, until now, the MNOs share their network elements partially or fully with the Mobile Virtual Network Operators (MVNOs) to provide service. In landline, “Local Loop Unbundling (LLU)” as discussed in detail by Sridhar (2019) is the methodology for sharing the network elements ranging from passive copper wire/ optic fires to bandwidth. Unfortunately, both MVNOs and LLU have not been successful in many countries due to economic reasons.

Broadly, following are the broad categories of NHs:

1. NH for Private Networks: Ideally suited for constructing and managing private networks for industrial uses.
2. Multi-Operator Small Cell as a Service (SCaaS): This type of NH does not have its spectrum. However, the NH function is accomplished by clustering many small cells and sharing the backhaul of MNOs.
3. Spectrum-based NHs: This type of NHs is a full-fledged local MNO, which has full right and have its own radio resources (shared or dedicated) and network that also hosts other diverse MNOs.

While the spectrum based NHs are licensed/authorized MNOs, the Scaas shall be authorized to provide interconnection to PSTN/PLMN/Internet. The NH for private networks are essentially for captive use and are not interconnected with public networks.

Earlier forms of neutral hosts were tower companies such as American Tower Corporation or Indus Towers that leased their passive tower infrastructure to multiple MNOs. However, in 5G, the sharing of the network elements by the neutral hosts to MNOs can range from passive infrastructure to network slicing, and even spectrum sharing. The MNOs on the other hand also benefit without substantial sunk cost in infrastructure deployment in local areas.

Apart from neutral hosts providing CNPNs, 5G Public Private Partnership Projects (5GPPP) and European Commission Horizon 2020 (H2020) initiatives, have also embraced the 5G-enabled neutral host framework for real-world deployments in three European cities: Barcelona in Spain, Bristol in UK, and Lucca in Italy (Fernández-Fernández, et al., 2021). A study by Fernández-Fernández, et al., (2021) indicates the benefits of using the neutral host model for deploying, provisioning, and managing vertical services over a virtualized and shared infrastructure.

Some countries including India have limited the CNPN solely for captive use and hence do not allow them to be interconnected with any PLMN/PSTN or the Internet (DoT, 2022). The investment in 5G networks is optimal, if the captive network can also connect to the PSTN/PLMN. This can be done by a neutral hosts who operate the CNPN as well as extend the connectivity to PSTN/PLMN. By restricting CNPNs not to be interconnected with the public networks, the economic viability of CNPNs is questionable. The regulatory guidelines should be augmented for incorporating neutral hosts in the equation. Neutral hosts bring in new dimensions of competition in the telecom sector, at the same time benefiting both the business and retail customers (Sridhar & Prasad, 12 Jul 2022). Depending on the type of NH, an appropriate licensing/authorization regime may be applied.

1.4. Conclusions

In this chapter, we contextualized the technology landscape in 5G and beyond as follows;

1) Increased modularization of the various network elements with more software embedded, resulting in unbundling of the telecom value chain;
2) Network slicing using Software Defined Network and Network Function Virtualization as a technology upgradation, leading to provisioning of differentiated services
3) The emergence of CNPNs as the differentiated offering for business and niche use cases.

References


Chapter 2. The Integrated Sphere of Coopetition of Digital Services and Diagonal Equity

Abstract

Telcos and internet companies are traditionally regarded as complementary. However, the growth of 5G technologies is seeing the growth of an integrated sphere of competition and cooperation between telcos and internet companies. The new elements of this competitive landscape stem from

- the hybridization of network provision,
- the growth of substitute services, and
- the jostling for a share of the pie earned by 'walled gardens'- end to end value networks comprising devices, connectivity services, and a variety of content and application companies.

The new dynamics occasion the application of a new regulatory framework – Diagonal Equity.

2.1. Introduction

Telcos and internet companies are traditionally regarded as complementary. This is not surprising. After all, internet companies provide content and applications that ride on connectivity provided by telcos. However, the growth of 5G technologies is seeing the growth of an integrated sphere of competition and cooperation between telcos and internet companies. The new elements of this competitive landscape stem from the hybridization of network provision, the growth of substitute services, and the jostling for a share of the pie earned by 'walled gardens'- end to end value networks comprising devices, connectivity services, and a variety of content and application companies. The new dynamics occasion the application of a new regulatory framework – Diagonal Equity.

Let us first acknowledge the continued element of complementarity between telcos and OTTs.

2.2. Complementarity of OTT Services

A greater demand for OTT services translates into greater use of the telco’s network. Hence, there is a strong element of complementarity between OTTs and telcos. For example, if one is wanting to share her current location, the map service and Internet messaging services complement each other.

When one searches for a product that she wants to buy, she might get promotional content from the same or related products by email or instant messaging, in which the search service complements the messaging/email services of the OTT providers. The table below illustrates possible complementary services provided by the OTT firms. The complementarity is further enhanced by the new nature of the telco, although this new development brings in elements of competition as well. Let us examine new elements of this competitive landscape in detail.
Table 2-1. Complementarity OTT services

<table>
<thead>
<tr>
<th>Services by OTT firms</th>
<th>Nature of Complementarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping services</td>
<td>Location service shared through messaging/ email</td>
</tr>
<tr>
<td>News services</td>
<td>Aggregated news shared through messaging/ email</td>
</tr>
<tr>
<td>Cloud services</td>
<td>Provides shared cloud services for storing messages/ email</td>
</tr>
<tr>
<td>Video streaming services</td>
<td>Complements the telecom services with broadcasting services</td>
</tr>
<tr>
<td>Internet Radio services</td>
<td>Complements the telecom services with broadcasting services</td>
</tr>
</tbody>
</table>

2.3. Hybridization of Network Provision

The formerly monolithic telecom network is experiencing a vastly heightened differentiation of functions and is acting as an integrator of a wider variety of provisioning entities (Gavrilovska 2020). Software development companies, cloud service providers that earlier would operate only in the OTT layer, are now active participants in network provision. Their entry increases the efficiency of 5G service but introduces a level of uncertainty for the telecom service provider that earlier had much smaller number of entities to deal with and had evolved stable commercial relationships with each of them. This included the managed services model under which equipment vendors would manage the telecom network owned by the telecom company, and the sharing of passive infrastructure under which tower companies would provide physical infrastructure on a shared basis to telcos. It remains to be seen how the new telecom architecture will affect the competitive strength of telecom companies. All one can say at this point is that certain OTT entities will now simultaneously be part of network provisioning while at the same time riding on the network.

Further, OTTs provide a number of substitute services that are in direct competition with telco services.

2.4. Substitutability of Services

The growth in over-the-top (OTT) messengers, which rely on the Internet to provide their services, has been accompanied with significant reductions in the usage and revenues of text messaging services in the past years. In 2015, the consumption of text messaging declined in Germany by 41%, Italy by 40% and the UK by 15.3% (AGCOM, 2015; Ofcom, 2015). While the limited empirical analysis carried out to date suggests complementarity between internet messengers and SMS, the studies are relevant to limited geographies, and constrained by the inherent difficulty of estimating demand for services which are not charged (Wellman, 2019).

Further, while the majority of OTT services ride on internet connectivity provided by telcos, there is a growing trend of OTTs venturing into the space of the provision of internet
connectivity. This phenomenon is enabled by the increasing availability of unlicensed spectrum and its potential to provide high quality connectivity. Similarly, the growth of VOIP services provided by OTT players could potentially take business away from traditional mobile or fixed line telephony.

One way to compare the OTT and MNO services is to examine their mutual substitutability. The following Table provides one such comparison:

**Table 2-2. Substitutability of MNO and OTT services**

(Adapted from Sridhar, 2019)

<table>
<thead>
<tr>
<th>Substitutability Factor of OTT services</th>
<th>Whether Substitutable</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice over IP, messaging, video calls and video broadcasting.</td>
<td>✓</td>
<td>These are very similar to services MNOs provide. In case of broadcast video, MNOs provides mobile video services. These are substitutable as they are functionally equivalent. Further, they can be provided over the Internet connection over Wi-Fi or any other mode without having a telco connectivity.</td>
</tr>
<tr>
<td>Voice over IP with termination on a public switched telecom network / public land mobile network</td>
<td>✗</td>
<td>These are not currently substitutable as this requires conversion of IP address to the telephone numbering system using an Internet-PLMN/ PSTN bridge. While this service can be provided by MNOs and VNOs as they are licensed to interconnect to PSTN/PLMN, regulations prohibit OTT communication service providers to do the same unless licensed or authorized.</td>
</tr>
<tr>
<td>Emergency services that require interconnection to PLMN/PSTN or other networks that connect devices to the Emergency Service Provider.</td>
<td>✗</td>
<td>Since OTT applications are closed apps and do not interconnect with other types of OTT services such as PLMN/PSTN, this service is not a substitutable service at present. However, even if the technology is available for this type of interconnection, since the Quality of Service provided by the OTT firms is based on the underlying Internet connectivity, the responsibility of providing Emergency services on OTT is difficult to enforce.</td>
</tr>
<tr>
<td>The Toll free 1-800 and 1-900 services.</td>
<td>✗</td>
<td>These services need inter-operability across originating and terminating service providers and services. These cannot be provided by the closed OTT service providers. Hence this service is non-substitutable.</td>
</tr>
<tr>
<td>Bulk messaging using broadcast services like SMS/ VoIP</td>
<td>✓</td>
<td>Current SMS/ Voice calls can be substituted by OTT based Messaging/ VoIP apps. This service is substitutable.</td>
</tr>
</tbody>
</table>

But as OTT services are beginning to substitute telecoms services, and OTTs and other entities are carrying out backward integration into the provision of the network, telcos are also engaging in forward integration into the application layer, and backward integration into the product and device space as they attempt to compete in this changing landscape.
2.5. Walled Gardens

The phenomenon of overlapping markets of telcos and internet companies is attended by the growth of ‘walled gardens’ (Hazlett et al 2011) comprising network operators, handset manufacturers, platform vendors, and content providers coming together to provide the entire suite of digital services and products. These ‘walled gardens’ produce products and services in competition with rival ecosystems, and often benefit from a ‘platform captain’ who provides coordinating mechanisms, rules, key products, intellectual property and financial capital. In several countries like the USA, handset manufacturers (e.g., Apple) and content providers (e.g., Google) have emerged as ecosystem/platform captains. In Handset Application Platforms (HAPs), handset manufacturers negotiate terms on which buyers of their phones (subscribers) gain access to given mobile networks through sharing of revenues with telcos, effectively purchasing network services to provide a superior experience to handset users. In a few countries (like Japan) telcos such as NTT Docomo and KDDI are the ecosystem/platform captains.

Platform captains generally derive business benefit from their pole position, especially in ‘closed’ ecosystems. Apple’s walled garden is an example of a closed business ecosystem. Participating in this ecosystem requires recognizing Apple’s IP and abiding by Apple’s rules. The rules are designed both to secure a superior customer experience and to protect Apple’s business model. While members of Walled Gardens gain from value added by the platform captain, they may aspire for the position of captain. This brings a new element of competition into the relationship between telcos and internet companies.

The simultaneous presence of complementarity and competition between telcos and OTTs implies that the digital space has become an integrated sphere of co-opetition.

2.6. Diagonal Equity: A New Regulatory Approach

Despite a growing convergence in services and growing competitive pressures within walled gardens, there is an asymmetric regulatory stance with respect to telcos and internet companies. Some of this asymmetry stems from fundamental differences in the nature of business. For instance, telcos use licensed spectrum as an essential input while Internet companies are not directly licensed to use spectrum. On the other hand, internet companies are subject to regulations of free speech and content regulation that are not directly applicable to telcos. However, the telcos are obligated to preserve subscriber privacy and confidentiality, comply with Government requests on call origination and related details, as well as make sure that the network is secure (DoT, 2022).

However, some of the asymmetry merely reflects a certain world view with regard to the regulation of competition across the two types of companies. Telecom companies are regarded as part of the core infrastructure of a country. They involve the use of critical natural

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1 The term ‘coopetition’ was coined by Adam Brandenburger and Barry Nalebuff to describe a situation in which competitors begin to collaborate along certain dimensions. In the case of the digital value network, the word is used to describe a situation in which collaborators begin to compete along certain dimensions. While the trajectory taken to arrive at a coopetitive state is diametrically opposite, the end state is similar. Hence, we believe the same word should be used.
resources like spectrum. On the other hand, OTTs are regarded as content companies not falling into the category of critical infrastructure. However, the hybridization of the network implies that software and content now forms an integral part of critical telecom infrastructure. Further, the embedding of the internet into every aspect of our lives implies that certain internet services, for instance internet search, can now be regarded as essential facilities. Given the criticality of the internet for a country’s security and prosperity, the current approach no longer suffices.

There is a strong case that similar principles should be applied to the regulation of telecom networks and certain aspects of the internet ecosystem. The rationale for such an approach is strengthened by the emergence of the integrated sphere of coopetition between telcos and OTTs. To clarify the nature of the recommendation, it is useful to revisit some fundamental principles of regulation.

2.6.1. Vertical, Horizontal, and Diagonal Equity

The objective of vertical equity leads to recommendations that bring about greater equality between entities that operate in the same industry, hence can be said to be similar, but are at different levels of financial resources. An example is to give startups in the search industry some benefits that enable them to compete with the larger search engines.

The objective of horizontal equity leads to recommendations of similar regulatory treatment of dissimilar entities, with similar or dissimilar resources. For instance, regulation could be used to bring parity in the regulatory approach toward the public sector company and private sector companies in an industry, or between two business schools, one with only women participants, and the other with a mixed intake of students.²

We introduce a new concept, that of diagonal equity. The objective of diagonal equity leads to recommendations of similar regulatory treatment of entities that operate in different industries. This stance flows from the recognition that there is a blurring of lines between the two industries that occasions a convergence of regulatory approaches.

In the world of 5G, as argued above, the time has come to move away from approaches that treat telcos as providers of essential services and thereby subject to more stringent regulation than OTTs. It is time to adopt principles of diagonal equity across telcos and significant OTTs, the details of which are discussed in the next section. This is not to say that the two kinds of entities are to be brought under the same regulatory umbrella. We propose a bifocal mode of regulation with razor sharp focus on a set of issues identified as critical to telecom connectivity, and, simultaneously, a clear picture of the transformative developments of the entire digital ecosystem that are underway. The intertwining of services provided by Telecom equipment vendors, content distribution networks, connectivity service providers, software vendors, cloud infrastructure service providers, and content and application developers makes such a holistic view necessary for appropriate policy and regulatory frameworks for any part of the entire digital ecosystem.

² For a conceptual discussion of vertical and horizontal equity, see the seminal discussion of Musgrave (1990).
We now apply the principle of diagonal equity to various issues in regulation.

2.7. Functional Equivalence

Regulatory approaches must recognize the functional equivalence of OTT communication services and standard telecom services despite their differing operational models under which telco service providers lease or own infrastructure while OTT communication providers do neither. The detailed implications of the recognition of functional equivalence are outlined in Chapter 3.

2.8. Net Neutrality

In the early days of the internet, there was a plug and play paradigm in which internet companies only had to connect to a hosting and internet service provider to gain access to the vast market of the world wide web. In such a world it was necessary to ensure the telcos did not misuse their gatekeeper functions. Net neutrality regulation was an outcome of this necessity.

While net neutrality was conceptualized by idealistic technologists seeking to create a Brave New World, it has a significant overlap with traditional concepts of competition regulation. In the language of mainstream economics, net neutrality regulation can be recast as stemming from three factors:

1. Significant market power of telcos
2. Vertical integration of telcos and internet companies.
3. Disadvantaged position of internet company vis-à-vis the end customer in the context of the two sided market of internet service provision.

The relevance of these factors is predicated on the underlying assumption that telecommunications constitutes an essential service. The greater the application of these three levers of classical regulatory principles to telcos, the lower the need for separate net neutrality regulation.

In the spirit of diagonal equity, if the economic principles driving net neutrality regulation apply to internet companies, then proportionate net neutrality-like regulations should be applied to them. This implies a move away from the traditional paradigm of net neutrality that aims to control only the power of telcos to adversely affect competition in downstream markets to ‘digital neutrality’ that recognizes and addresses the ability of a variety of entities not restricted to telcos to inhibit competition in the digital ecosystem (see chapter 5 for more details).

Let us take the example of search engines. A large percentage of the traffic on the internet starts from a search query (BrightEdge, 2023). This percentage becomes greater if one factors

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3 On the other hand, opponents of net neutrality regulation base their arguments on the contestability of telecom networks, the investment disincentives resulting from such regulation, and the beneficial aspects of vertical integration in terms of the integration of complementary externalities between connectivity services and the applications that ride on top of them.
the traffic that may have gone directly to a website but which had found the site through a prior search. Hence search can be considered as an essential facility. The search market is highly concentrated with Google playing a dominant role in the market. Google's share becomes greater if we leave out China where Baidu has a monopoly. Hence, search neutrality is arguably as important as net neutrality in promoting competition. This importance of search neutrality becomes heightened in the presence of vertical integration between the search engine company and some of the companies appearing in search returns. Finally, search engines can also be considered as a two sided markets with multi-homing websites that need to advertise on all search engines on one side, and single-homing end users that primarily use one search engine on the other side. Hence the search engine tends to make its gains via the advertiser. This increases entry barriers for smaller companies and new entrants. In other words, all three factors that make net neutrality legislation necessary in the case of telcos are also present in the search engine market. To what extent have comparable regulations been applied? Please see chapter 5 for more details, including the formulation of a new approach of ‘Digital Neutrality’.

2.9. Interconnection and Data Portability

A similar exercise of identifying underlying economic principles and applying them equitably across telcos and internet companies needs to be carried out in the case of interconnection. For telecom networks, interconnection is mandatory for all licensed operators. The setting of interconnection charges must reconcile the objectives of facilitating competition, and enabling wholesale cost recovery and promoting investment in infrastructure to achieve rapid diffusion of telecom services. Low access charge would dis-incentivize infrastructure investment and ignore potential economies of scale and network externalities. On the other hand, high charges would disincentivize market entry and amount to exercise of market power. An underlying driver of interconnect regulation is the perception of voice telephony as a basic need.

Similar principles can be invoked for VOIP services, social networks, instant messengers, and indeed any service that exhibits network externalities. Inability to interconnect restricts competition. Given the role being played by social networks and other internet sites in the politics of a country, the ability to interconnect, like voice telephony, could well be regarded as a public good. Hence some form of interconnect regulation is relevant for internet companies just as it is for telecom regulators, and we must ask if it has been levied to the required degree.

The ability of an end user to migrate to an alternate network is a mirror image of his/ her ability to connect with users in other networks. Telecom networks are required to facilitate such migration by measures like mobile number portability. This facilitation increases the contestability of the telecom market and mitigates the possible abuse of a dominant position. One could argue that end users could benefit from similar possibilities of portability with respect to internet messengers, social networks, email applications, and so on. Therefore, just as it is important to insist on mobile number portability to promote competition in telecom markets, it is important to hold internet companies to similar standards with regard to data portability. To what extent has this been done? (see chapter 6 for more details).
2.10. Universal Service

Governments aim to achieve universal provision of basic telecom services through a universal service obligation imposed on telcos. This obligation takes the form of a universal service levy and also certain rollout obligations.

Moreover with the internet traffic going up exponentially especially in the pandemic years, has led to unprecedented strain on the telcos who have expended huge resources to maintain their networks driven mainly by traffic from a few leading OTT players.

Global debate has started around the need for OTT players to pay a fair share for the development of the networks that are used by them to deliver their services. The European Digital decade package has committed to developing adequate frameworks so that all market actors benefiting from the digital transformation assume their social responsibilities and make a fair and proportionate contribution to the costs of public goods, services and infrastructures, for the benefit of all Europeans. Recently, the ‘fair share’ resolution was included in a competition policy document by members of the European Parliament. They voted in favour of a ‘policy framework’ that would call on big tech companies to contribute to telco capex budgets (Telecom TV, 14 June 2023).

An interesting case study is that of South Korea, where SK Telecom asked Netflix to contribute to the cost of network expansion when Netflix traffic exploded on SK Broadband’s network 26 fold over two years. Netflix sued SK Broadband, claiming it had no obligation to negotiate with or pay for the use of SK Broadband’s network. However this argument of Netflix was rejected by the court in June 2021, holding that since Netflix is receiving network services in the form of management of network quality and maintenance work to maintain its explosive surge of viewers, it must pay a reasonable price to be negotiated between the parties. While Netflix has filed an appeal against the Seoul court decision, which is currently pending, meanwhile, In December 2020, the National Assembly of South Korea promulgated the so-called Netflix Law which requires content providers that content providers that attract an average of more than 1 million users per day and account for more than 1 percent of Korea’s internet traffic are responsible for ensuring network stability and to pay a fee to cover network use (Feigenbaum & Nelson, 2021).

In a world where a profusion of connectivity services have emerged, OTT service providers cannot continue to ‘ride for free’ The universal service levy, which is presently being borne by the infrastructure provider/telco needs to be actually paid by those who utilize the infrastructure being set up by others. Hence, they need to pay a levy to ensure the quality of the public internet. This can be charged both as a IUC charge in case of OTT Communication players and as a Broadband Infrastructure levy in case of other OTT players. Hence, significant OTTs, such as OTT video service providers, shall pay a fee to cover their use of the networks and contribute to a Broadband Infrastructure Fund to finance the rollout of the connectivity infrastructure that carries their traffic (see Chapter 7 for more details).

2.11. Moderation of Regulatory Levies
The telecom companies make a wide variety of payments to the government including upfront spectrum charges, spectrum usage charges, and license fees. Spectrum prices in India is amongst the highest in the world even without normalising for per capita income.

In contrast, OTTs are not required to comply with any regulatory levies or even pay telecom companies for the use of their Telecom infrastructure. Further, while the same rates of Goods and Services Tax (GST) are applicable on OTTs and telcos, the way in which OTTs recognize revenues implies that much of their operations goes untaxed. This needs to change (see chapter 3 for more details).

In sum, the digital space has become an integrated sphere of co-opetition between telcos and OTTs. Hence there is a need to examine whether they are being subject to similar regulatory burdens when the underlying triggers for intervention are similar. Of course, in areas where the nature of business predicates unique regulation for telcos and internet companies, separate regulatory stances need to be formulated.

As will be specified in later chapters, regulators in the EU have already adopted many of the regulatory stances espoused in this chapter. It is time for the all regulators to develop an integrated view of digital communications. Specifics on licensing, spectrum regulation, Net Neutrality regulation, interconnection regulation, and universal service regulation are provided in chapters 3–7 respectively.

2.12. Conclusions

In this chapter the following points are highlighted:

1) The growth of 5G technologies is seeing the growth of an integrated sphere of competition and cooperation between telcos and internet companies.
2) This occasions the development of a new approach – diagonal equity – that envisages similar regulatory treatment of telcos and significant OTTs, hitherto regarded as dissimilar entities on account of the perceived nature of the telco as an essential service, and hence subject to dissimilar regulatory burdens.
3) The application of the approach of diagonal equity in the realm of functional equivalence between OTT communications service providers, and standard telco services; net neutrality; interconnection and data portability; universal service; and in the moderation of regulatory levies is highlighted.

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Chapter 3. Licensing: From the communications convergence bill to functional separation and infrastructure integration

Abstract

The Indian telecom industry is one of the largest and fastest-growing telecom markets in the world. Since the introduction of mobile technology and the internet, the industry has grown exponentially, and the licensing frameworks have evolved to keep up with the changing times. In this chapter, we explore the new technological and economic requirements of the industry and the corresponding changes required in the licensing framework - functional separation and infrastructure integration. We begin by highlighting some key developments in the thought process involved in licensing.

3.1. Background and Existing License Structure

The Communications convergence bill 2001 (Govt, 2001) was drafted at a time when the paradigm of ‘one pipe one service’ under which telephony, internet, and broadcasting were provided through different media - fixed line or wireless, broadband, and cable/over the air - was on its way out. From a technological point of view, the prospect of ‘triple play’ in which all three services - telephony, internet, and broadcasting - could be provided using the same medium had become a reality. Further, each service could be provided using any of the three media. This multiplicity of possibilities spawned a bold new vision based on two fundamental principles:

i. convergence of infrastructure functions in an integrated entity, and
ii. functional separation of services from Infrastructure.

A new entity - the network infrastructure facilities provider - was conceptualized that could integrate all the different communication modes to serve network service providers who would operate in the services layer and target the end customer.

At the time of the drafting of the bill, the governance frameworks of Indian telecommunications, information technology and broadcast were decoupled from each other. These came under different ministries and departments, though there was a single regulator – Telecommunications Regulatory Authority of India (TRAI) to oversee the both telecommunications and the broadcasting sector.

Telecommunications services were provided by obtaining a license that came bundled with spectrum. Further, the licensing terms and conditions, specified the technology for wireless services. After the “limited mobility” controversy, in November 2003, the Indian government announced the guidelines for Unified Access Service License (UASL), which allowed the use of any technology (both wire-line and wireless) for the provisioning of network access service,
with an option for the Basic Telecom Operators (i.e. wireline service providers) to migrate to UASL by paying the prescribed fee (Sridhar, 2012). After some incremental changes, such as the delinking of spectrum from the license in 2012, the Unified License regime was announced by the Government in 2013 (DoT, 2013), under which entities obtain a single license in the first stage, and then subsequently obtain service level authorisations for various services including internet, National long distance, International long distance, satellite communication, and VSAT based closed user group services. Spectrum is delinked from the license and has to be obtained separately. The unified license represents a step towards convergence as it allows a single entity to provide telephony as well as internet services. However, it stops short of incentivizing the functional separation of the infrastructure and services layers to nudge the industry in the direction envisioned in the CCB.

The current structure of the UL is presented in Figure below (DoT, 2016; DoT, 19 Apr 2016; DoT, 19 Jun 2018; DoT, 30 Aug 2018):

**Figure 3-1. Existing License Structure**

The following are the notable features in the existing license structure:

The introduction of the Virtual Network Operator (VNO) license in 2016 enabled the separation of network provisioning from service provisioning to some extent. While the UL(VNO) access service license area is much the same as the UL Access Service license areas, the granular division of service areas down to district level for VNO category B licenses (with associated limitations on providing wireline service only) indicates that the current telecom circles need a re-visit. Though various amendments, the Internet Telephony service provisioning by various
license categories evolved and is discussed in details in the later chapter on interconnection regulation (see Chapter 6).

In 2019, the Department of Telecommunications (DOT) under its ‘Propel India’ mission requested the TRAI to furnish recommendations on enabling the unbundling of different layers of the telecommunications value chain through differential licensing. The aim was ‘reforming the licensing and regulatory Regime to catalyse investments and innovation and promote ease of doing business’. In response, in 2021, The TRAI recommended the creation of a separate authorisation of Access Network Provider (network layer) under the Unified License to provide network services on wholesale basis to virtual network operators (TRAI 2021). The access network provider would be responsible for all the network related terms and conditions specified in the Access Service Authorization under Unified License. However, clauses related to service delivery would not be applicable to this category of providers.

While the Access Network Provider was meant to be a new entity in the telecom landscape, the extant entities were meant to continue and no incentives were recommended to encourage a transition to a functionally separated industry. As a result, the concept of the Access Network Provider did not gain much traction. In fact, the DoT has not yet amended the UL to include Access Network Provider only authorization.

The Draft Telecom Bill 2022 (DOT 2022) defines “telecommunication services" to include a wide variety of services including broadcasting services, electronic mail, voice, video and data communication services, fixed and mobile services, internet and broadband services, satellite based communication services, internet based communication services, machine to machine communication services, and over-the-top (OTT) communication services. By recognising the profusion of services possible in a 5G world, and by including OTT communication services in the list of Telecommunication services, the draft Telecom bill acknowledges the functional equivalence of a wide variety of services. This creates a rationale for reducing the barriers to entry for service providers by unbundling services and infrastructure layers. To this extent, it represents a step in the direction of the functional separation of services and infrastructure. However, like previous initiatives, not much has been done by way of introducing incentives that would, at the very least, help to overcome the inertia involved with moving to a new industry structure.

**3.2. The heightened need for convergence and functional separation**

The need for convergence in the infrastructure layer and functional separation between structure and services that has been articulated with varying degrees of intensity since 2001 is now more pressing than ever before.

**3.2.1. Functional separation**

The need for functional separation is being driven by two forces:
i. Rapid innovation in the services layer: As highlighted in the Draft Telecom Bill 2022, there is a wide variety of services and service providers coming into being as the world adopts 5G technologies. To facilitate this innovation, it is important to ensure that the multiplicity of service providers do not need to own elements in the infrastructure layer in order to enjoy a level playing field with other service providers. This is sometimes referred to as the Bell Doctrine (Joskow 1998) that was used in the anti-trust case against AT&T in 1982. Under this principle, when an industry has two layers comprising an essential network/infrastructure layer and a layer that rides on top, the two layers must be unbundled in order to allow a new entrant or a startup in the overriding layer to compete without having to incur the heavy capital expense of building out the infrastructure layer.

ii. Greater investment and sharing needed in infrastructure layer: As 5G technology will operate in small cells, the fibre and tower network will have to be expanded manifold. Efficiency requires that this expanded infrastructure be provided in a neutral and cost effective manner to the various service providers in order to avoid inefficient duplication of network costs. Therefore, it is necessary that the infrastructure layer operate at an arm’s length from the services layer. Steps have already been taken in the UL(VNO) license that separates the service from the infrastructure layer. However the concept of an infrastructure only operator has not yet been introduced.

3.2.2. Convergence in the infrastructure layer

The need for convergence in the infrastructure layer is being driven by the greater unbundling in the infrastructure layer. The telecom network has evolved from an elementary architecture comprising radio equipment and physical infrastructure to a software-led ecosystem that includes cloud storage companies, software developers, and municipalities, besides the traditional network entities (see Chapter 1). This unbundled ecosystem would be of great benefit to service providers, provided there is an entity - referred to as the network infrastructure facilities provider in the CCB, the Access Network Provider (network layer) in the TRAI 2021 recommendation - to integrate all the various elements. In the absence of such an entity, transactions costs for service providers would become unmanageable as they would have to negotiate separately with individual members of the infrastructure eco-system. The main arguments along with their counter-views are highlighted in the Table below:

<table>
<thead>
<tr>
<th>Table 3-1. Functional Separation and Convergence in Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Separation</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Direction of innovation</strong></td>
</tr>
<tr>
<td><strong>New versus Old Investment</strong></td>
</tr>
<tr>
<td><strong>Convergence of network elements</strong></td>
</tr>
</tbody>
</table>

28
Hence, we recommend a functional separation of infrastructure and services and an integration/convergence of the infrastructure layer.

The proposed structure is shown below:

![Figure 3-2. The Layered approach to Digital Communications](image)

A noteworthy feature of our approach is that we are treating virtual network operators that lease network capacity from the network operator, and OTT communication service providers that do not lease network capacity as imperfect substitutes from the point of view of regulation. This is because the end user treats communication services provided by telcos and by OTTs as substitutes. Thus, these services are functionally equivalent even though they are operationally disparate and hence need to be viewed from the same regulatory lens.

This approach is in line with the Directive (EU) 2018/1972 of the European Parliament and of the Council (EU 2018) that states: “end-users increasingly substitute traditional voice telephony, text messages (SMS) and electronic mail conveyance services by functionally equivalent online services such as Voice over IP, messaging services and web-based e-mail services. In order to ensure that end-users and their rights are effectively and equally protected when using functionally equivalent services, a future-oriented definition of electronic communications services should not be purely based on technical parameters but rather build on a functional approach...While ‘conveyance of signals’ remains an important parameter for determining the services falling into the scope of this Directive, the definition should cover also other services that enable communication. From an end-user’s perspective it is not relevant whether a provider conveys signals itself or whether the communication is delivered via an internet access service.”

Of course, one must also be sensitive to the differences in these two kinds of entities that stem from their different operational models\(^5\). There are associated implications for provisioning of

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\(^5\) One perceived difference between VNOs and OTT communications service providers is that VNOs are able to use the publicly assigned numbering system. However, the EU treats any entity whose users are able to connect
emergency services, compliance to net neutrality and so on which are discussed in later chapters, taking in to account the possibility of functional separations in the regulatory framework.

Further, the current licensing framework has evolved with a number of amendments. The terms and conditions are very different for each type of service authorization. In a converged digital era, it may be preferable to simplify the existing licensing framework in to a simple tiered structure of a few types.

3.2.3. OTT Broadcasting and Video Services

Video downloads, video streaming and pay-per-view video services provided by the OTT video service providers consume large amount of bandwidth. This traffic provides stress on the underlying network. Revenue from OTT video segment is projected at US$ 3.76 bn in 2023 and expected to grow to $5.51 by 2027, with an annual growth rate of 10.01% (Statista, 2023). The largest segment is Video Streaming (SVoD) with a market volume of US$1.70 bn in 2023. The user base for OTT video segment is about 528.90 m. Revenue in the OTT Video segment is projected to reach US$3.76bn in 2023. According to Neumann, et al (2022), a share of around 80% of the Internet traffic comes from the three segments of video, social media and video games, out of which the share of video segment is the highest.

Most of the MNOs also provide video services. Notable example in this segment is Jio Cinema, owned by Viacom18, which was launched in 2016. The official broadcaster of Indian Premier League (IPL) cricket 2023, Jio Cinema, clocked 147 crore views in the week end of IPL 2023 (BT, 3 Apr 2023). Similarly Airtel XStream is the OTT video service provided by Airtel.

With a 20 percent share, Amazon Prime Video and Netflix are the leading OTT video services in India. Disney’s recently acquired Hotstar occupies third place with a 17 percent market share, With roughly 10% of the market, ZEE5, which has a substantial base in Hindi, Telugu, Tamil, and Malayalam, is in fourth place. These are followed by Jio Cinema, Alt Balaji, Sony Liv, SUN NXT, and Aha Apps have the highest OTT market share in India’s top 10. The network providers need to accommodate this demand by upgrading the investment on their network infrastructure. There are the proponents to the argument that CAPs shall pay the ISPs network fee for carriage of their traffic as it puts disproportionate traffic load on their networks. In a highly cited case of Netflix vs. SK Telecom, the ISP tried to pass on the Sending Network Payment charges to the CAP, which went through multiple litigations in South Korea (Feigenbaum & Nelson, 2021). On the other hand, the opponents, mainly the large CAPs argue that such levies will dissuade them to place their cache servers nearer to the ISPs point of presence which in turn will affect quality of their video services. It is also mentioned that large CAPs have then own SDNs and their cache servers, they can take decisions on where to place their cache servers depending on whether they need to pay carriage charges to the ISPs.

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to number based systems as a number-based interpersonal communications service. Hence, OTT comms providers would fit into this category.
Towards, this we recommend that the OTT video service providers, including OTT broadcasters pay a ‘broadband infrastructure levy’ which will then be distributed to the telcos/ISPs based on the volume of total traffic carried in their networks. We do not propose direct payment of carriage charges by the CAPs to telcos/ISPs as this is prone to litigation as exemplified in the South Korea case.

Further, when a telco/MNO provides video services, functional separation of network provider and OTT video services will clearly demarcate the boundaries of operations between the two, resulting in unambiguous and equal regulatory treatment across the industry.

Video services are also being intensely used by EdTech firms for providing live online session and video streaming of lessons (e.g. upGrad, Byjus, Simplilearn, Coursera); by HealthTech firms for providing teleconsulting and telemedicine. The consumption of bandwidth by these firms over their platforms is also increasing. Hence, much like OTT video services, the bandwidth heavy OTT services in education and health should also be considered for the broadband infrastructure levy.

3.3. A new licensing regime

This section elaborates upon a differentiated licensing regime for the infrastructure and communications services that would reflect the functional separation of infrastructure and services and an integration/convergence of the infrastructure layer. Three separate levels of regulation are used. Licensing implies that the entity requires prior permission to operate and must pay license fees. General authorisation implies that entities must satisfy certain criteria but do not need to pay license fees. Registration means that entities only need to register to operate. They can commence operation without prior permission. However, they may be restricted from operating in case they do not follow the general guidelines. A broad overview of this regime is provided below.

i. In line with our regulatory model of functional separation, we create a two layer system of licenses and authorisations for infrastructure and services respectively.

ii. In the infrastructure layer, we conceive of an entity - the network provider, that is entitled to bid for spectrum, and that integrates together all the entities in the physical and network layer - CDNs, cloud storage providers, tower companies, optical cable providers etc., to provide network bandwidth on wholesale basis to communication service providers. This is in line with TRAI’s recommendations on unbundling (TRAI, 2021). The licensed network provider is authorized to acquire radio spectrum for exclusive use in the deployment of networks in a relatively monopolistic market. License fees is 3% of revenues. Network Providers shall be mandated to provide equal access on equal commercial terms to communications service providers. They need to fulfill rollout obligations and are charged a universal service levy.

iii. In the communication services layer, we distinguish between entities that lease network bandwidth from the network provider, namely the VNOs; and those that are untethered from the underlying network, namely OTT communications providers.

iv. Both VNOs and OTT communications providers are divided into significant and non-significant service providers, based on the proportion of traffic carried by them. All
VNOs and significant OTT communications providers are charged a broadband infrastructure levy at the rate of 3% of their revenues from India operations obtained from public networks, net of revenues flowing from specialized services that involve direct contracts with the network operator. In line with regulation of the European Union, the revenues include all forms of remuneration including direct fees, and advertising, as well cases where payment is by a third party and not by the service recipient.

v. Since OTT broadcast and video services demand large capacity from the underlying broadband, we propose that the broadband infrastructure levy be applicable to them as well. This levy should be extended to other OTTs depending on their bandwidth consumption. As with communications service providers, the applicable revenues should be revenues obtained from public networks, net of revenues flowing from specialized services that involve direct contracts with the network operator. A self-auditing process shall be initiated by the network providers to submit quarterly reports on bandwidth consumption by the OTT apps to TRAI, based on which the collection of broadband infrastructure levy shall be initiated by the Department of Telecommunications.

vi. The proceeds of the broadband infrastructure levy are used to fund broadband infrastructure across the country, especially in urban and semi-urban areas.

vii. Quality of service requirements shall be applicable to all communication service providers, namely the VNOs, and OTT communications providers.

viii. Emergency service requirements will be applied on VNOs.

ix. Net neutrality will be applicable on all VNOs in the form of minimum quality of service of the public network.

x. Network Security/ Data Privacy & Data Protection, and Lawful Interception will be regulated through contemporaneous specific laws on these topics. These are discussed in details under interconnection regulation.

xi. As the heterogeneity of market likely to increase with 5G, we suggest that the granularity of LSAs be increased in line with the UL(VNO) access service license for the communication services layer

The structure is shown in the table below:

**Table 3-2. Details of the Licensing Framework**

<table>
<thead>
<tr>
<th>Type of Licensing</th>
<th>OTT Communications Service Providers</th>
<th>VNOs</th>
<th>Network Provider</th>
<th>Other entities in infra layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Authorization, if significant, else Registration</td>
<td>General Authorization</td>
<td>License required, license fees to recoup administrative</td>
<td>Registration</td>
<td></td>
</tr>
</tbody>
</table>

---

3.4. Migration Plan

The new structure should not be mandated but incentivized through an incentive structure as follows:

i. Entities that undertake accounting/legal separation will pay spectrum usage charge only on revenue of wireless network services.

ii. The Universal service levy is applicable to network providers, as a mandate for being offered exclusive resources such as spectrum for roll-out of networks.

iii. Broadband Infrastructure Levy by communication service providers used to fund broadband infrastructure in urban and semi-urban areas, a facility that will directly facilitate the core business model of telecommunications.

iv. Network providers allowed to undertake network slicing only if they are functionally separate from service providers or, at least adopt accounting separation.

<table>
<thead>
<tr>
<th>Interconnection regulation</th>
<th>Universal interconnection and portability between all types of service providers</th>
<th>Universal interconnection and portability between all types of service providers</th>
<th>Universal interconnection and portability between all types of service providers</th>
<th>No regulation (governed through contractual agreements)</th>
</tr>
</thead>
<tbody>
<tr>
<td>License and Regulatory Fees</td>
<td>Fixed Authorization fee + Broadband Infrastructure Levy @3% as percentage of AGR for Significant OTT Communication and Video Service Providers</td>
<td>Fixed Authorization fee + Broadband Infrastructure Levy @3% as percentage of AGR</td>
<td>License Fee + Universal Service Levy @5% as percentage of AGR + Annual Spectrum Usage charges as percentage of AGR as applicable</td>
<td>Fixed Registration Fee</td>
</tr>
<tr>
<td>Emergency Services</td>
<td>Yes, if significant</td>
<td>Yes, if significant</td>
<td>No (applied through contractual agreements)</td>
<td>No (applied through contractual agreements)</td>
</tr>
<tr>
<td>QoS</td>
<td>Yes</td>
<td>Yes</td>
<td>No (applied through contractual agreements)</td>
<td>No (applied through contractual agreements)</td>
</tr>
<tr>
<td>Net Neutrality</td>
<td>No</td>
<td>Yes, minimum QoS for public networks</td>
<td>No (applied through contractual agreements)</td>
<td>No (applied through contractual agreements)</td>
</tr>
</tbody>
</table>
A wide spectrum of industry configurations are possible within our regulatory framework ranging from the current vertically integrated structures to completely unbundled formations and everything in between. The precise configuration would be dynamically determined via the unfettered choices of industry participants.

3.5. Revenue Estimates

We project revenue estimates for the Government as per our recommendation and compare it with the revenue accrued under the current licensing regime. The baseline used is the AGR, license fee at 8% (3% license fee + 5% USL/ Broadband Infrastructure Levy) and Annual Spectrum Usage Charges (SUC) as provided by TRAI (2023). Following are the other data that we have used in the calculations:

1. The OTT communication providers such as WhatsApp and Zoom earn revenue through (i) business users and (ii) advertising. The annual revenue from WhatsApp business is estimated to be around $1 billion/year (MoneyControl, 2023).
2. Estimated annual revenue of OTT video service providers is $3.5 billion (Statista, 2023).

### Table 3-3. Regulatory Fees as per the Current Regime

<table>
<thead>
<tr>
<th>Quarterly Estimates Based on TRAI Dec 2022</th>
<th>AGR (Cr)</th>
<th>Existing License Fee Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>License Fee @ 3%</td>
<td>USL @ 5%</td>
</tr>
<tr>
<td>Annual Adjusted Cross Revenue of UL (Q3 2022)</td>
<td>51,000</td>
<td>1,530</td>
</tr>
<tr>
<td>Annual Adjusted Cross Revenue of ISP (Q3 2022)</td>
<td>3,700</td>
<td>111</td>
</tr>
<tr>
<td>Total</td>
<td>54,700</td>
<td>1,641</td>
</tr>
</tbody>
</table>

### Table 3-4. Regulatory Fees as per the Proposed Regime

<table>
<thead>
<tr>
<th>AGR</th>
<th>Proposed License Fee Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR</td>
<td>License Fee @ 3%</td>
</tr>
<tr>
<td>Annual AGR of Network Providers @ 50% of the Current Regime</td>
<td>25,500</td>
</tr>
<tr>
<td>Annual AGR of VNOs @ 50% of the Current Regime</td>
<td>25,500</td>
</tr>
<tr>
<td>Estimated AGR of OTT Communication Providers: $1 billion</td>
<td>2,000</td>
</tr>
<tr>
<td>Estimated AGR of OTT video services including ad revenue, pay per view, video downloads and video streaming: $3.5 billion/year</td>
<td>7,000</td>
</tr>
</tbody>
</table>
The above tables show the results of the comparison of the existing license fees with the proposed license fee structure. Though the quarterly estimated regulatory fee is less in our proposed structure, we expect that it will match up soon due to the increased usage of broadband for both communication and video services.

We have simulated the scenario for 2026, with the following assumptions:

1. A CAGR of 20% in AGR of network providers and VNOs for the next 3 years.
2. Growth of OTT communications and video services revenue to $7 billion by 2026 (Statista, 2023a).
3. Reduction of license fee from 3% to 1%; USL and BIL from 5% to 3%. Spectrum charges as percentage of AGR remain the same.

Table 3-5. Regulatory fees as per Proposed Regime in 2026

<table>
<thead>
<tr>
<th></th>
<th>Proposed License Fee Regime by 2026</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AGR</td>
</tr>
<tr>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Annual AGR of Network Providers with CAGR of 20%</td>
<td>45,000</td>
</tr>
<tr>
<td>Annual AGR of Communication Service Providers with CAGR of 20%</td>
<td>45,000</td>
</tr>
<tr>
<td>Estimated AGR of OTT Communication Providers : $2 billion by 2026</td>
<td>4,000</td>
</tr>
<tr>
<td>Estimated AGR of OTT video services including ad revenue, pay per view, video downloads and video streaming: $7 billion/year by 2026</td>
<td>14,000</td>
</tr>
<tr>
<td>Total</td>
<td>108,000</td>
</tr>
</tbody>
</table>

From the Table, we can see that the regulatory fee in fact increases due to increase in revenue of various operators and service providers, despite the reduction in fee as percentage of AGR. Hence we recommend that the licensing fee structure be revamped taking in to account the growth of broadband networks and usages across segments of the society. This will also send positive signal to the industry to invest in infrastructure and services to provide quality and affordable broadband services to the nation at large.

3.6. Conclusions

The notable features of our proposal are as follows:
1. We create a two layer system of licenses and authorisations for infrastructure and services respectively.

2. In the infrastructure layer, we conceive of an entity - the network provider, that is entitled to bid for spectrum, and that integrates together all the entities in the physical and network layer to provide network bandwidth on wholesale basis to communication service providers. Network Providers shall be mandated to provide *equal access on equal commercial terms* to communications service providers. They need to fulfill rollout obligations.

3. In the communication services layer, we distinguish between entities that lease network bandwidth from the network provider, namely the VNOs; and those that are untethered from the underlying network, namely OTT communications providers.

4. The OTT communications providers are divided into significant and non-significant service providers, based on the proportion of traffic carried by them. All VNOs and significant OTT communications providers are charged a broadband infrastructure levy at the rate of 3% of their revenues from the public network. The proceeds of the broadband infrastructure levy are used to fund broadband infrastructure across the country, especially in urban and semi-urban areas.

5. Since OTT broadcast and video services demand large capacity from the underlying broadband, we propose that the broadband infrastructure levy be applicable to them as well.

6. Quality of service requirements shall be applicable to all communication service providers, namely the VNOs, and OTT communications providers.

7. Emergency service requirements will be applied to VNOs.

8. Net neutrality will be applied on all VNOs in the form of minimum quality of service of the public network.

The licensing and regulatory framework needs to be sensitive to the greater modularity possible with 5G technologies. This chapter reflects our attempts to design a licensing structure that would nudge the industry toward exploiting the new opportunities, in line with conceptualizations that date back to the Communications Convergence Bill 2001.

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KSEDUhttps://karnatakastateopenuniversity.in/top-10-popular-ott-platforms-in.html


Chapter 4. Spectrum Regulation

Abstract

In this chapter, we discuss the details of radio spectrum management for commercial 5G mobile services as follows:

1. The legacy of spectrum allocation in India including the methodology that is used currently.
2. Analysis of spectrum prices in India across various bands and over time.
3. Analysis of the determinants of spectrum prices in India.
4. Role of unlicensed spectrum as complementary to licensed spectrum.
5. The challenges of coexistence in the C-band, including spectrum safety requirements and spectrum for Captive Non Public Networks
6. The spectrum needs for satellite communication and the coexistence of satellite networks and terrestrial 5G networks
7. The future of spectrum licensing including light licensing and dynamic spectrum sharing.
8. The regulatory structure for spectrum management and the need for regulatory autonomy in spectrum allocation and management.

We conclude this chapter with policy steps towards effective spectrum management in the era of 5G and beyond.

4.1. Introduction

Radio frequency spectrum refers to a subset of frequencies of electromagnetic spectrum. Electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation, which travel through space exhibiting wave-like behavior. The electromagnetic spectrum extends from below the low frequencies used for modern radio communication to gamma radiation at the high-frequency end. Radio spectrum refers to the part of the electromagnetic spectrum that can be used for communication. It corresponds to frequencies from 3 KHz to around 300 GHz (Prasad & Sridhar, 2014).

Spectrum is managed at an international as well as national level for allocation and assignment. The central body coordinating at an international level is the International Telecommunications Union (ITU) with jurisdiction over spectrum from 9 KHz to 275 GHz.

Below the ITU are organizations at a regional and national level. For instance, the Confederation of European Post and Telegraph Agencies and the European Union operate at a Pan-European level, and various country jurisdictions within Europe operate in the individual domains.

In India, the National Frequency Allocation Plan (NFAP) is the policy document which outlines the allocation of different parts of the frequency spectrum for various purposes. The plan is
entrusted to the Wireless Planning & Co-ordination group (WPC) under the Department of Telecommunications, Government of India.

An overview of radio spectrum, across telecom, and broadcasting are provided in the following figure:

![Figure 4-1. Taxonomy of Radio Spectrum](adapted from Sridhar, 2019)

There are the following conflicting or overlapping uses of spectrum in certain bands:

1. In 5G, the 6 GHz spectrum band is sought after by both the MNOs and Internet firms. While the MNOs want it to be licensed, the Internet firms propose it to be unlicensed. This is also being used fixed GEO satellite services.
2. The coveted mid-band in 5G is 3.3-3.6 GHz band that is used for providing Public Land Mobile Network (PLMN) is also sought after by enterprises for constructing CNPNs.
3. The 700 MHz band which has been traditionally provided for terrestrial broadcasting, is finding alternative use in providing 4G/5G services in rural and remote areas.
4. The 60 GHz band, originally used for microwave backhaul is also being sought for unlicensed use.

### 4.2. Method of spectrum allocation in India

In case of access spectrum, the same has been allocated through auction since 2010. The method of auction used in India since 2010 is the widely used Simultaneous Multiple Round Ascending Auction (SMRA), details of which are given below (Prasad & Sridhar, 2014):
1. Bidders simultaneously submit bids in each auction, round by round, until a round is reached in which no new bids are received in any auction. This gives bidders’ flexibility to target each region based on the progress of bidding in all the regions. For example, if bidding is in progress in only one remaining region with all the other regions closed, and if it goes very high, then some bidders may want to re-open bidding in other regions which are substitutes for the last remaining region.

2. After each round, the auctioneer announces a ‘provisionally winning bidder’ if that bidder had the highest bid in that round. A “provisionally winning bidder” is responsible for paying his bid price unless outbid by another bidder in a later bidding round. In earlier versions of the simultaneous ascending auction, bidders could choose their bid increment. But this freedom became a signaling device in the hands of the bidders. Hence they were restricted to selecting from a drop down menu of possible increments, and more recently, to an automatic five or ten percent increment every round.

3. Bid withdrawals were considered to be a useful tool to give flexibility to bidders to build a desired package of items. However, it became another tool for signaling as operators made and then withdrew bids in certain regions in order to signal their interest in other regions and induce like behavior in their competitors. Currently, the possibilities for withdrawals are present but limited.

4. In early auctions, bidder identities and their respective bid amounts were public information. Given the need for operators to partner in order to provide national coverage, and for technologies used to be compatible, it was felt that revealing bidder identities would enable more informed bidding. However, this transparency became a conduit for collusion. As a result, now bidder identities are not revealed till the end of the auction, and only the provisionally winning bid amount declared.

5. In order to ensure that bidding in the rounds proceeds in an orderly manner and results in the revelation of market information for the benefit of all concerned, it is important to ensure that bidders act in a consistent manner through the auction. Inconsistency may be occasioned by not having thought through one’s strategy or from a snake in the grass strategy whereby bidders lie quiet in early rounds and then surprise others by entering and bidding aggressively in later rounds. In order to achieve consistency of bidder behavior, different regions are assigned ‘bidding units’ based on their business potential, and bidders required to indicate the total number of bidding units they are interested in through an upfront payment. This determines their ‘eligibility’, i.e. the upper cap on the number of bidding units they can bid for in each round. In order to ensure regular participation in line with eligibility, there are ‘activity rules’ that stipulate that a bidder must score a minimum percentage of their eligibility in each round, i.e. participate in a minimum number of auctions. This percentage increases as the rounds proceed. As the auction progresses and prices rise, the activity rule forces bidders to place binding pledges at the current prices or leave the auction.

6. The winners of the simultaneous ascending auction, the only ones willing to pay the provisionally winning bid of the last round plus the increment stipulated by the auction designer, pay the bid of the second highest bidder plus the bid increment. The auction is therefore a second price auction, with an additional five or ten percent added on, in line with the bid increment.

The Enhanced SMRA (ESMRA) is a two-stage auction format that provides a simultaneous multiple-round clock stage for generic lots to determine the quantity of lots won of each product, followed by an assignment stage to determine the specific assignment. In India, we
have been using ESMRA for allocation of spectrum. A lot in the auctions held in India mean blocks. For example, in the 800 MHz, the blocks are available in sizes of $2 \times 1.25$ MHz and the bidder can bid for multiple blocks.

Some of the important parameters to be set by the auctioneer in the auction include the following:

1. Reserve price which is the starting bid price in the first round of the auction process; and price increment at each clock round;
2. Eligibility points based on certain criterion including the bank deposits the bidders have submitted before the start of the auction;
3. The amount of available spectrum in each band, including the lot size and number of slots on block.

Of the above, reserve price is proven to be the major determinant of the winning bid price in the auctions conducted in India (Sridhar & Prasad, 2021).

Microwave backhaul has thus far been assigned administratively, with payment of spectrum charges on an escalating basis for incremental assignments.

### 4.3. History of Spectrum Prices in India

In case of access spectrum, the Spectrum reserve prices in India have been higher than international averages. The figures in Appendix-IV provides an overview of the spectrum reserve prices and winning bid prices (in Int$) across various spectrum bands. Following are the observations:

1. The reserve prices for most bands have been increasing over the years. This is partially due to reserve price being calculated based on the winning bid price in the last held auction.
2. Until 2015, the average winning bid prices were a bit a higher than the reserve prices, However, since then, the winning bid prices did not go any higher than the reserve prices indicating the higher price barriers in the spectrum auction.

There have been many studies that indicate the high reserve prices is one of the reasons for spectrum prices in India to be higher than international averages (Sridhar & Prasad, 2021).

Appendix-IV provides an overview of the available versus allocated spectrum across various spectrum bands. Following are the observations regarding the same:

1. While until 2015, the allocated spectrum was on par with available spectrum across bands, from then onwards, the allocated spectrum was much lower than the available spectrum across bands.
2. The above indicates that the uptake of spectrum across bands have been less, possibly due to higher reserve prices.

In a cross country study of spectrum prices, Sridhar & Prasad (2021) point out the following:
1. Reserve price is one of the significant determinants of spectrum prices. There is a strong positive correlation between reserve price and winning bid price. However, since 2016, the winning bid prices are very close to the reserve prices across spectrum bands, indicating thereby that the winning bid prices may not be indicative of true valuations.

2. Spectrum availability has a negative impact on spectrum prices. Higher availability, indicative of higher supply of spectrum tends to lower the spectrum prices. Despite the availability of spectrum, the MNOs picked up smaller amounts, indicative of factors that have deterred demand for the spectrum bands. It can be reasonably hypothesized that higher reserve prices could be one of the reasons for the same.

4.4. Analysis of variables that affect Spectrum Price

In order to analyze what impacts spectrum prices in India, we compiled a panel data set that covered all the spectrum auctions took place during 2010-2022. The summary of the various auctions is given below in Table 3-1:

Table 4-1. Summary Statistics of Spectrum Auctions held in India

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price per MHz per pop(population) (in Int $)</td>
<td>0.97</td>
<td>2.03</td>
</tr>
<tr>
<td>Reserve Price per MHz per pop (in Int $)</td>
<td>0.68</td>
<td>1.36</td>
</tr>
<tr>
<td>Average number of bidders</td>
<td>5.82</td>
<td>2.41</td>
</tr>
<tr>
<td>Total available spectrum</td>
<td>17309.59</td>
<td>28864.49</td>
</tr>
<tr>
<td>Total spectrum allotted</td>
<td>131.4</td>
<td>414.45</td>
</tr>
</tbody>
</table>

We performed an OLS linear regression to understand the correlation between the following independent variables and the winning bid price. The results are tabulated below:
Table 4-2. Analysis of the determinants of spectrum prices in India

| Coefficient | t-value | P (>|t|) |
|-------------|---------|---------|
| Intercept   | -0.68   | -4.39   | 0.00*** |
| Reserve Price/MHz/Pop | 1.19 | 38.24 | 0.00*** |
| Number of Bidders | 0.15 | 8.50 | 0.00*** |
| Population Covered (in Millions) | -0.0024 | -2.32 | 0.02* |
| Available Spectrum (MHz) | 7.40×10⁻⁷ | 0.50 | 0.62 |
| Dummy for Sub GHZ Band | 0.24 | 2.28 | 0.02* |

The analysis indicates the following:

1. Reserve price has a significant positive effect on spectrum price. Any $1 increase in reserve price will increase the winning bid price by as much as $1.19.
2. The number of bidders in the auction, representative of competition, also has a significant positive effect on winning bid prices.
3. The dummy for the low band indicates a positive effect on winning bid price, meaning thereby that the sub GHZ band invites higher winning bid prices compared to the reference group that consists of all prices for spectrum above 1 GHz.
4. It is surprising that the spectrum available does not have a significant effect. It is partially due to the data set containing the total amount of available spectrum put on auction across all bands. Efforts will be made to run the model with band wise available spectrum amount to see the effect of the same on spectrum prices.

4.5. Role of unlicensed spectrum: Wi-Fi as Complement or Substitute

4.5.1. Wi-Fi Networks

Radio spectrum for mobile services is always rationed out after much deliberation amongst government policy makers, regulators and mobile operators. However, a silent revolution took root in large U.S. University campuses in the nineties in the form of Wireless Local Area Networks (WLAN) later ratified by manufacturers as Wireless Fidelity (Wi-Fi). Like the Internet and Web, wireless LANs became a mass market technology due to open standards that unleashed powerful competitive forces and innovation. While many WLAN technologies were being sold throughout the 1990s, it was the establishment of the 802.11b standard by the IEEE, that set the stage for mass market development. After many other market entries, by the summer of 2002 there were an estimated 15 to 18 million 802.11b networks. Wi-Fi gained popularity as it operated in the Industrial, Scientific and Medical (ISM) band of 2.4 - 2.4835 GHz (i.e. in between licensed S-bands of 40 and 41). There are many devices that operate in the ISM band including cordless phones at home. However, using an ultra-wide band of 20 MHz, Wi-Fi uses spread spectrum technology along with low power levels for indoor coverage, thus minimizing interference problems with devices that operate in the same band.
For larger areas or outdoor spaces such as parks and plazas, directional antennas and amplifiers could be used to sculpt a coverage zone using the meager one watt of power permitted by the FCC for unlicensed operators. As in the case of other open source movements, the proponents of WLAN had the utopian dream of completely undermining the stranglehold of cellular and landline telecommunications companies.

No longer having to wait and pay huge sums of money for spectrum, the Internet Service Providers (ISPs), quickly adopted the new technology and started developing Wi-Fi hot spots in public area, cafeterias and restaurants to enable Internet access. The IEEE 802.11 forum with appropriate modifications to the physical layer, encoding algorithms and multiplexing techniques has kept the evolution of Wi-Fi access networks almost at par with the 2G/3G/4G networks of mobile operators. Table 3-3 illustrates the evolution of Wi-Fi technologies.

Table 4-3. Summary of Wi-Fi Technologies

<table>
<thead>
<tr>
<th>IEEE 802.11 Standard</th>
<th>Release</th>
<th>Frequency (in GHz)</th>
<th>Max Data Rate (in Mbps)</th>
<th>Indoor Range (in M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Sep 1999</td>
<td>5</td>
<td>54</td>
<td>35</td>
</tr>
<tr>
<td>b</td>
<td>Sep 1999</td>
<td>2.4</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>g</td>
<td>Jun 2003</td>
<td>2.4</td>
<td>54</td>
<td>38</td>
</tr>
<tr>
<td>n (Wi-Fi 4)</td>
<td>Oct 2009</td>
<td>2.4/5</td>
<td>600</td>
<td>70</td>
</tr>
<tr>
<td>.ac (Wi-Fi 5)</td>
<td>Nov 2011</td>
<td>2.4/5</td>
<td>7 Gbps</td>
<td>70</td>
</tr>
<tr>
<td>.ad (Wi-Gig)</td>
<td>Jan 2013</td>
<td>2.4/5/60</td>
<td>7 Gbps</td>
<td>10</td>
</tr>
<tr>
<td>.ay</td>
<td>2019</td>
<td>60</td>
<td>20-40 Gbps</td>
<td>30</td>
</tr>
<tr>
<td>.ax (Wi-Fi 6)</td>
<td>2020</td>
<td>2.4/5</td>
<td>9.6 Gbps</td>
<td>30</td>
</tr>
<tr>
<td>Wi-Fi 6E</td>
<td>2020</td>
<td>2.4/5/6</td>
<td>19.2 Gbps</td>
<td></td>
</tr>
<tr>
<td>.be (Wi-Fi 7)</td>
<td>2024</td>
<td>6</td>
<td>46 Gbps</td>
<td></td>
</tr>
</tbody>
</table>

Due to changing needs of the user (for instance downloading High Definition video), there is a need for upgrading the speed of the Wi-Fi networks beyond the current levels. The IEEE standard group has been working on the next generation Wi-Fi – IEEE 802.11ac, that is designed to work in the 5 GHz range. The 5 GHz spectrum range has less interference compared to 2.4 GHz in which appliances such microwave and cordless phone work. Further using Multi User Multiple Input, Multiple Output (MU-MIMO), the theoretical throughput of IEEE 802.11ac networks has broken the Gigabit per Second barrier. The standard specifies ultra-
bandwidth extending up to 160 MHz thus enabling high data rate capabilities. On 20th February 2013, the FCC took a major step for relieving congestion caused by huge data traffic in public locations such as airports and hotels. The commission proposed a larger portion of about 135 MHz to be released in the 5 GHz spectrum band for promoting IEEE 802.11ac – as a means to provide high bandwidth access (Sridhar, 2012). Further, it shall be noted that unlike in 4G LTE where support for licensed spectrum was taken up at later stages of the standard setting process, the requirements for accessing unlicensed spectrum from the start of 5G NR (Dahlman, et al. 2020).

In India, the amount of spectrum release for unlicensed use include 83.5 MHz in 2.4 GHz and about 605 MHz in 5 GHz (GoI, 2022). In UK, much like in India, 83.5 MHz is unlicensed in 2.4 GHz, while 1,105 MHz is available in 5 GHz.

4.5.2. Wi-Fi 6 and Beyond

IEEE 802.11ax, is the first amendment in the Wi-Fi family to go beyond small indoor environments, and aim to optimize its performance in large outdoor deployments. Although, it enhances the nominal data rate by 37% compared to Wi-Fi 5, it aims at providing a 4x improvement in terms of throughput and spectrum efficiency in dense deployments, through new features such as Orthogonal Frequency Division Multiple Access (OFDMA), Multi-User MIMO (MU-MIMO), and spatial reuse. At the same time, Wi-Fi 6 reduces the power consumption per device. Whereas Wi-Fi operates in the 2.4 and 5 GHz frequencies until now, the Wi-Fi 6 E standard includes 6 GHz spectrum band (5.925 – 7.125 GHz) as well. The 6 GHz band is also expected to be a key mid-band spectrum for 5G expansion, given increasing demand from consumers and enterprises. The next World Radiocommunications Conference (WRC-23) will consider the 6425-7125 MHz range for IMT identification in Region 1. TRAI recommendation for IMT identification also includes 6425-7125 MHz band. which has already been assigned in frontier markets (e.g. USA, Korea, UK etc.) and is expected to receive similar allocation elsewhere (e.g. Europe). In the Americas, like the USA, Brazil, Chile, and Guatemala have also recently opened up all 1200 MHz of the 6 GHz band for unlicensed use. In Asia, South Korea has recently announced the near future unlicensed use of 1.2 GHz (5.925 to 7.125 GHz) in the 6 GHz band. Recently, 5.925-6.425 GHz spectrum has been proposed by the European Commission (EC) under part 15 rules for the unlicensed access. Hence, the amount of the unlicensed spectrum available in Europe is 500 MHz. In Europe, both Low Power Indoor (LPI) and Very Low Power (VLP) (without any outdoor operation) are approved to operate across 500 MHz. The list of countries that have delicensed part or full frequencies in the 6 GHz spectrum band is included in Appendix V. However, in India, the recently released NFAP 2022 does not mention any license exemptions for the 6 GHz band (GoI, 2022).

A considered and calibrated approach needs to be adopted for 6 GHz band so that 5G expansion is not jeopardized, at the same time garnering the benefits of Wi-Fi. The 5G and Wi-Fi 6 enhancements have narrowed the disparities in the legacy use cases that the cellular and Wi-Fi technology families may each address, while at the same time creating opportunities to address new market demands for applications with evermore intensive throughput and Quality of Service requirements. The first effect tends to bring the two technologies closer as potential substitute alternatives for meeting end-user demand (Kumar & Oughton, 2022).
Many of the equipment vendors have positioned 5G and Wi-Fi 6 to coexist providing enhanced indoor coverage and seamless integration.

These developments indicate some sort synergy and convergence between the macro cellular network technologies standardized by 3GPP and micro coverage technologies such as Wi-Fi standardized by IEEE.

4.5.3. The unique case of 60 GHz band

The V-band (57-71 GHz) is suitable for short range transmission as is the characteristic of high frequency radio beam. This band is typically split into two sets of frequencies: 57-64 GHz and 64-71 GHz. While some countries have allowed V-band for use by Telcos and Internet Service Providers in both the sets, some have restricted licensed use to the lower band of 57-64 GHz. However, on both the sets, the bandwidth is 7 GHz and hence provides large capacities. This band can be used for short range communication, both for both point-to-point and point-to-multipoint configuration that makes this V-band an interesting case study (Sridhar, 27 Oct 2020).

Wireless access systems in this 60 GHz band in unlicensed mode have been developed through a series of amendments in IEEE 802.11 protocols (notably .ad and .ay), and has been adopted by the Wireless Gigabit Alliance (WiGig) to provide Gigabit speed “wireless fibre”. The above developments have enabled firms to innovate around this very important band to offer wide variety of solutions. The Internet companies such as Facebook and Google have been working on technologies using WiGig standards to deploy high speed public networks.

On the other hand, Telcos lobby for licensing V-band for high-powered Line of Sight point-to-point links that can act as high-speed back-haul. OfCom, the UK telecom regulator, after its Regulatory Impact Assessment (RIA) of V-band opted for license exempt authorization method. The European countries such as Austria, Belgium, Poland, Slovakia and Spain along with China, Korea, Malaysia, Australia and New Zealand have unlicensed the V-band. The United States Federal Communication Commission, through a number of regulatory directives has released spectrum in 57-71 GHz for license exempt use. The TRAI has recommended delicensing this band for access and light licensing for backhaul (TRAI, 2014). However mixed use will entail interference studies before any allocation can be made.

4.5.4. The co-existence of 5G NR-U and IEEE 802.11 networks

While 3GPP and IEEE have approached the spectrum management from the opposite sides, namely licensed versus unlicensed, there is a convergence of ideas in 5G New Radio. New Radio-based access to Unlicensed spectrum (NR-U) intends to expand the applicability of 5G NR access technology to support operation in unlicensed bands by adhering to Listen-Before-Talk (LBT) requirement for accessing the channel (Patriciello, et al., 2020). The 3GPP Release-15 based model extends the capability of 3GPP radio to be used in the unlicensed bands complying at the same time with the regulatory requirements. The 3GPP Release 16 promotes the NR-U in both the 6 and 60 GHz spectrum paving way for the coexistence of Wi-Fi 6E and Wi-Gig networks respectively (Saha, 2021).
Further, many countries including the U.S., allow unlicensed devices operating at extremely low powers throughout the 6 GHz bands. These devices referred to as very low power (VLP) devices can operate within the exclusion zones of incumbent users and in both indoor and outdoor environments. Such VLP devices are critical in enabling personal area network applications such as wireless AR and VR through wearable devices and in-car connectivity (Naik, et al., 2020). These developments indicate that coexistence of 5G and Wi-Fi and seamless connectivity is possible in the 6 and 60 GHz bands.

4.6. Coexistence in the C-Band

The C Band that extends from 3100-4200 MHz is one of the bands more sought after by the MNOs for providing 5G connectivity. This band, called as the C-Band has the following attractive characteristics:

1. Due to high frequencies, the antenna sizes can be smaller, making it possible to install in street furniture such as lamp posts, thereby providing ubiquitous coverage.
2. The band is less susceptible for attenuation due to rain, thereby making it an ideal candidate for satellite TV broadcasting.
3. The band is also ideal for constructing CNPNs as organizations can construct their captive in-premise networks or in places such as airports, and seaports providing 5G connectivity.
4. There is a possible interference especially in the higher frequencies with radar altimeters used in aircrafts that operate at 4200-4400 MHz (Sridhar, 9 Dec 2022). In India, the Director General of Civil Aviation has also raised concerns over the C-Band frequencies allotted in the recent 2022 auction to the MNOs.
5. However as the MNOs have been allocated 3300-3670 MHz, there is enough guard band to prevent any possible interference with the radar altimeters (Sridhar, 9 Dec 2022). MNOs have highlighted this and also cited international practices, where much smaller buffer are maintained to address the concerns by aviation authorities. Japan, for instance, that has permitted 5G operations in 4.1 MHz band.

In view of the above, this allocation of the most sought after C-band for 5G IMT services has often been tricky for the regulators.

4.6.1. The CBRS Band in the US and SAA

Federal Communications Commission (FCC) proposed the release of 150 MHz in 3550-3650 MHz (3.5 GHz C-Band) currently used for military and satellite communication for shared use in 2012. In 2012 the FCC issued a Notice of Proposed Rule Making (3.5 GHz NPRM) to create a new Citizens Broadband Radio Service (CBRS) centered around a spectrum access system (SAS). The SAS envisions three tiers of service: (i) Incumbent Access, (ii) Priority Access, and (iii) General Authorized Access (GAA). Priority Access and GAA tiers would be licensed for users with automatic authorization to deploy small cell systems similar to installing Wi-Fi access points. SAS deploys a dynamic spectrum database to assign and monitor spectrum use and associated interference, thereby protecting higher level users from the usage by lower level users. A GAA tier would be assigned on an opportunistic and non-interfering basis within
designated geographic areas. There have been proponents and opponents of the SAS in the CBRS band. A detailed review of the technical architecture of SAS is presented in (Sohul, et al. 2015). Sohul, et al (2015) also indicate the diverse interest groups in CBRS, including the Internet firms such as Google for SAS administration, the MNOs, the Network Equipment Manufacturers, satellite communication firms, and standard development organizations such as IEEE. A detailed review of stakeholder interests indicates that the cellular industry raised two important questions: whether the proposed framework provides sufficient certainty to attract investment, and whether the existing technology is capable of supporting the proposed framework. According to the cellular industry, the primary reason for the uncertainty is the introduction of Dynamic Spectrum Management (DSM) concepts and the inability of the existing technology to support such a dynamic approach. Even in the stakeholder consultation, it was evident that the SAS is technically complex for appropriate implementation.

4.7. Spectrum for Satellite Networks

As terrestrial 5G mobile networks are being rolled out across countries, there is renewed interest in integrating Non Terrestrial Networks (NTN), primary one being the Low Earth Orbit (LEO)) satellite networks (SatNets), as a complement to terrestrial networks. Towards this, Starlink operated by Musk owned SpaceX and OneWeb promoted by Bharti Global have launched about 2,500 and 648 LEO satellites respectively at an altitude of about 1,200 Kms, with the objective of promoting global broadband connectivity.

There are primarily three main use cases for integrating SatNets with terrestrial 5G networks: (i) service continuity to provide seamless handover and roaming between terrestrial networks and SatNets especially in the case public safety and emergency situations when terrestrial networks get disrupted due to natural catastrophes such as floods and earthquakes, thereby improving network resilience; (ii) service ubiquity to provide 5G services in unserved and underserved areas of the world, thereby bridging the digital divide; (iii) service scalability that utilizes the unique capabilities of SatNets in multitasking and broadcasting similar content over a large geographical area (Darwish, et al., 2021). The SatNets can provide service not only to stationary but on in-motion users. The Federal Communications Commission (FCC) has recently authorized Starlink satellite internet to vehicles in motion including ships, trucks and recreational vehicles.

In the history of telecommunications, satellites and terrestrial networks have always been considered as two independent ecosystems, and their standardization efforts have proceeded independent of each other. In view of the above advantages of synergizing terrestrial networks with SatNets, the standard setting organizations such as Third Generation Partnership project (3GPP) started integrating SatNets in the standardization process. As an extension to terrestrial networks, satellites were first mentioned in a deployment scenario of 5G in 3GPP Release 14. This was to provide 5G communication services for areas where terrestrial coverage was not available and also to support services that could be accessed more efficiently through satellite systems, such as broadcasting services and delay-tolerant services. Through Releases 15, 16, 17, and 18, 3GPP launched several standardization activities to support the integration of SatNets and 5G terrestrial networks (Darwish, et al., 2021).
Apart from providing access service directly to the users, SatNets can also be used as backhaul links (that connect different terrestrial Points of Presence). Interestingly, wireless communications through LEO satellites over long distances is proven to be 1.47 times faster than communication over the same distance through terrestrial optic fibre (Leyva-Mayorga, et al., 2020). It is this advantage along with global coverage provide a strong use case for SatNets as backhaul to complement terrestrial optic fiber networks especially in rural and remote parts of the country for providing enhance Mobile Broad Band (eMBB).

There are still many issues yet to be resolved including the frequencies to be allocated for satellite broadband, the methodology of allocation whether it be administrative assignment or through auctions, relatively higher cost of consumer equipment, and the placement and interconnections of SatNets with terrestrial public landline/ mobile networks at the ground stations.

The radio spectrum required for SatNets, broadly lie in Ku band (12-18 GHz) and Ka band (27-40 GHz). Starlink has the FCC approval for use of both Ku and Ka bands while approval is pending for the use of E- band (71-86 GHz). The OneWeb system uses the Ku band for communication between the user terminal and the satellite while Ka band is used for communication between satellite and earth station for connecting to the Internet. As per the National Frequency Allocation Plan (NFAP) 2018 of India (DoT, 2018), most parts of these bands in India are reserved for Fixed Satellite Services provided using Geo-Stationary satellites. The Ku and Ka bands are widely used for Direct to Home Television broadcasting in most countries, including India. The Government of India announced the allocation of 26 GHz spectrum for terrestrial 5G communication, as in most countries, thereby paving way for possible deployment of LEO systems in the 28 GHz band. These require close frequency coordination between the Departments of Telecommunications, Departments of Space and Departments of Information and Broadcasting for allocation of the above common frequency bands across terrestrial 5G networks, LEO SatNets and satellite Television broadcasting respectively. Further, there are questions of auctioning or not of satellite spectrum. Since satellite spectrum is used for broadcasting, and is always used in a non-exclusive mode by appropriate coordination mechanisms, it is an international practice not to use auction and assign the spectrum for exclusive use of certain operators. However, the DoT and TRAI have been discussing about auctioning satellite spectrum much like spectrum for terrestrial mobile services (Business Line, 27 Oct 2022).

The other major challenge in SatNets is the cost of user terminal and access charges to the end users. A recent research analyzing both Starlink and OneWeb concludes that the standalone LEO systems have distinct cost advantage only of the density is less than 0.1 person per square km compared to terrestrial broadband networks (Ogutu & Oughton, 2021). Hence it is to the advantage of SatNet providers to integrate their networks with terrestrial 5G networks to improve the cost economies.

Despite these challenges, the integration of LEO SatNets with terrestrial 5G networks along with the associated standardization activities and regulations will provide the much needed resilient and ubiquitous future communication network systems.
4.8. New approaches to effective spectrum management

In view of the evolution of 5G and beyond networks, country regulators all over the world have been revising their strategy and rules in response. We describe certain best practices that are being formulated by the regulators across the countries.

4.8.1. Light licensing and flexible spectrum regulation

In recent years, some OECD countries are considering simplified licensing procedures to allow sharing under light licensing regimes, including Australia, New Zealand, and the United Kingdom (see Table). Australia’s area wide apparatus license (AWL) in the 26 and 28 GHz bands is one example of the light licensing approach, which demonstrates a relatively light administrative burden and openness to a wide number of services and users, depending on availability of spectrum in the requested area.
Table 4-4. Examples of Light Licensing Sharing Approaches

(Source: OECD, 2022)

<table>
<thead>
<tr>
<th>Sharing Model</th>
<th>Country</th>
<th>Band</th>
<th>Services sharing spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light licensing model – simplified procedure</td>
<td>Australia</td>
<td>26 and 28 GHz</td>
<td>Area-wide apparatus License (AWL); will share spectrum with class licensees (unlicensed in Australia framework) in the 24.7-25.1 GHz band and individual IMT license in the 25.1-27 GHz band. AWL licenses can be used for a range of services (incl. FWA, mobile wireless broadband, private networks, FSS and to support IoT)</td>
</tr>
<tr>
<td>Light licensing model – simplified procedure</td>
<td>New Zealand</td>
<td>2575 MHz-2620 MHz</td>
<td>Managed Spectrum Park (PSP) licenses are intended to support the provision of local or regional communication services. MSP licenses providing communication service must coordinate among themselves to avoid interferences</td>
</tr>
<tr>
<td>Light licensing model – simplified procedure</td>
<td>United Kingdom</td>
<td>Mobile bands covered under mobile trading regulations</td>
<td>Local Access License allow other users to access unused MNO spectrum and is envisaged to support other mobile use cases (e.g. private networks, mobile coverage (rural/ indoor), fixed wireless access). However, the shared user does not have to employ the same technology as the incumbent licensee</td>
</tr>
<tr>
<td>Light licensing model – simplified procedure</td>
<td>United Kingdom</td>
<td>1800-2390 MHz; 2400 MHz, 3.87-4.2 GHz, and 26 GHz; 116-122 GHz, 185-190 GHz</td>
<td>Shared Access License allows other users to access spectrum in requested spectrum band and areas; dependent on interference assessments with existing users; intended to support mobile use cases (e.g. private networks, mobile coverage (rural/ indoor), fixed wireless access)</td>
</tr>
<tr>
<td>Concurrent shared access (“club use”)</td>
<td>Italy</td>
<td>26 GHz</td>
<td>Mobile services sharing between licensees</td>
</tr>
<tr>
<td>Concurrent shared access (“club use”)</td>
<td>Slovenia</td>
<td>26 GHz</td>
<td>Mobile services sharing between licensees</td>
</tr>
<tr>
<td>Flexible use geographic overlay licenses</td>
<td>U.S.</td>
<td>2.5 GHz</td>
<td>Initiated in July 2022 and not yet finalized</td>
</tr>
</tbody>
</table>

4.8.2. Flexible Spectrum Management: from static to dynamic approaches

The current spectrum management regime using the “command and control” approach has been criticised by researchers and industry experts for its inefficient use of scarce spectrum resources. Some of the methods proposed towards a forward looking spectrum management and regulation include the following:

1. Perpetual licenses with full technical and service neutrality, so that any spectrum can be used for any application and without concerns as to time constraints for recouping any investments (Freyens & Alexander, 2015).
2. Leasing or Shared access so that any unused spectrum can be exploited by others (Bhattarai, et al., 2016).
3. Trading that provides fluidity of spectrum rights to allow the market to work efficiently in use of spectrum (Freyens & Alexander, 2015).

Even though spectrum trading and sharing guidelines have been announced by the DoT in 2015 (DoT, 2015), the sharing is limited to static sharing of spectrum under certain contractual
conditions. There are also certain constraints in both trading and sharing as specified in the guidelines. Also, as of now, leasing has been allowed only for captive non public networks. Hence there is a need for flexible spectrum management, including dynamic spectrum access and sharing as being practiced in many countries.

A brief overview of international best practices in flexible spectrum management (OECD 2022):

a) Ofcom in its “Spectrum Strategy for the 2020s” noted the potential of automated spectrum management tools. Another way to facilitate spectrum sharing may be through dynamic spectrum access (DSA), which could be combined with automation techniques that allow users to access spectrum in a dynamic way for a defined period or in a defined area. A more recent example of a dynamic approach can be seen in the automated frequency coordinators, called Spectrum Access Systems (SASs), that facilitate coordination between and among the three tiers of users in the CBRS band (3.5 GHz) in the United States.

b) A further dynamic approach is being implemented in Japan. The Ministry of Internal Affairs and Communications (MIC) has established a “dynamic spectrum sharing management system” to be used to manage shared access to the 2.3 GHz (2 330 - 2 370 MHz) band between incumbent users (broadcasting and governmental use) and mobile services. Incumbent users input their spectrum use (e.g., frequency, location, day, time) into the sharing system and mobile operators then apply for shared use. Depending on the request and availability, the system decides whether the mobile operator can access the spectrum. In May 2022, MIC has assigned KDDI Group a license to use this 2.3 GHz band spectrum for five years.

c) While the rules for access by unlicensed devices under the coordination of a TVWS geolocation database system were finalized several years ago by the United States, Canada, and other countries, there has been increasing adoption of the technology in recent years. The Airband initiative in the United States, led by Microsoft, and more recently the designation of geolocation database system administrators in Canada, is resulting in broader commercial use of the technology, primarily to support rural connectivity. Under Canada’s framework, the white space database system coordinates spectrum access of white space devices by providing a list of available channels and the permitted power levels for each one to the devices. It also keeps track of the geolocation information it receives from the devices to dynamically manage spectrum.

d) Another dynamic approach to managing unlicensed use of spectrum can be seen in the United States, which established an automated frequency coordination (AFC) system to manage spectrum use by unlicensed, standard-power wireless access points in the 6 GHz band. The 6 GHz band has existing incumbent use in the fixed, mobile, and fixed satellite services (FSS), with fixed services being the largest user group. The AFC would determine exclusion zones and permit unlicensed access to the bands only at certain frequencies and locations outside of these zones to protect fixed services in particular (e.g. point-to-point stations), as well as radio astronomy sites.
4.8.3. Dynamic Spectrum Sharing

Realizing the need for efficient use of radio spectrum due to exponential increase in wireless broadband penetration and associated data usage, countries around the globe are transitioning from the traditional command and control mode of spectrum management to flexible use. Country regulators and policy makers that define a stringent set of administrative rules for assignment and usage of spectrum have started to adopt flexible use policies including creation of an active secondary spectrum market and deployment of associated technologies. In fact, several new licensing schemes have emerged from regulatory entities and from the industry to enable a more efficient spectrum usage, such as opportunistic usage of TV white spaces (TVWS) (ECC, 2013), light licensing (ECC, 2019), Licensed Shared Access (LSA) (ECC, 201), and Spectrum Access System (SAS) (FCC, 2012)]. The need for associated regulatory governance and licensing mechanisms have also been stressed in Peha (2012), and Prasad & Sridhar (2014).

European Commission released ECC Report 205 on Licensed Shared Access (LSA) in February 2014 [3]. LSA is a complementary spectrum management tool that facilitates the introduction of new users in a frequency band while maintaining incumbents’ existing services on the same band. LSA ensures a certain level of guarantee in terms of spectrum access and protection against harmful interference for both the incumbents and LSA licensees. In April 2013, Finland was the first country to trial the LSA on 2.3 GHz band, where the incumbents — Program Making Special Events (PMSE) licensees that use professional wireless camera links of the broadcasting and TV production companies, share their spectrum on a dynamic basis with the mobile operators. LSA is incorporated in the regular process of the Radio communications Agency Netherlands. It is compulsory for the PMSE sector to use the LSA booking system in the 2.3-2.4 GHz band. This obligation is incorporated in the licenses of PMSE users in this band. Also, the National Regulatory Authorities (NRA) of Italy, France, Russia and Portugal have piloted LSA. The spectrum sharing in these cases has either allowed the MNOs to increase their public network capacity or enterprises to deploy Captive Non-Public 5G Networks (Sridhar & Kokkinen, 4 July 2022).

Sharing of spectrum under appropriate regulatory structure between MNOs and other spectrum users is possible in the unlicensed commons spectrum as well. One such example is the coexistence of the 4G-Long Term Evolution (LTE) technology being deployed by the mobile operators with Wi-Fi providers in the 5 GHz band. Additionally, within the public mobile networks, MNOs may deploy Dynamic Spectrum Sharing (DSS) to ensure gradual migration from 4G-LTE to 5G.

However, Sridhar & Kokkinen (4 July 2022) point out that whatever may be the methodology that we choose, an important regulatory initiative at this stage would be to set up a country-wide geospatial spectrum database that contains the spectrum in use across different areas by the various operators. Without this first step, the dynamic spectrum access methods will not take off in the country.

4.9. Conclusions
Given the legacy of spectrum management in India, following are the policy steps that the sector regulator and policy makers can possible take to usher in the era of 5G and beyond:

1. While the Enhanced SMRA is being used a standard and well proven auction methodology for allocation radio spectrum, the outcome of the auction is determined by many configuration parameters, especially the reserve prices set at the initial clock round. Regulator shall consider the fixing of the reserve price for different bands in accordance with international prices.

2. The DoT shall provide visibility and roadmap of the amount of spectrum available for commercial mobile services so that the MNOs and others interested in acquiring spectrum can plan accordingly.

3. Flexible approaches to spectrum management including spectrum trading and sharing shall be implemented for optimal and efficient use of spectrum. To enable the same, the Government shall initiate the construction of a geo spatial spectrum database.

4. The carve out of spectrum for CNPNs shall be discussed with stakeholders as these have positive as well as negative consequences. Appropriately it is suggested that spectrum carve outs for CNPNs shall be purpose limited and within a much limited geographical area as is being practiced internationally. The appropriate pricing mechanism shall also be devised.

5. Any allocation of 6 GHz or 60 GHz band for unlicensed use should be carefully considered so that it does not impact the rollout and growth of licensed mobile services, at the same time nurturing the benefits of unlicensed spectrum for Wi-Fi services. Partial allocation and allocation for indoor use shall be considered.

6. Coexistence of 3GPP unlicensed with Wi-Fi 6E in 6 GHz shall be actively considered as per 3GPP Release 16.

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Chapter 5. From Net Neutrality to Digital Neutrality

Abstract
Classical principles of net neutrality no longer suffice to address the vastly transformed business and technological possibilities of the digital ecosystem powered by 5G technologies. Network function virtualization, software defined network slicing, and cloud Radio Access Networks provide opportunities for integration of content and applications firmly with the underlying network. The view that network providers alone have the power to misuse their gatekeeping role and discriminate is no longer applicable, as in 5G and beyond networks, the content and application providers have become dominant in the value chain. This chapter presents a new conception of net neutrality and proposes an overarching framework - digital neutrality - that extends objectives of net neutrality to the entire digital economy.

5.1. Introduction: What is Net Neutrality?
Since the controversial term “Net Neutrality” (NN) was coined by Professor Tim Wu of Columbia Law School in 2003, most of the debates on NN revolved around the harmful consequences of Telecom and Internet Service Providers (TISPs) exercising control over the data traffic in their networks. The focus on TISPs in the net neutrality debate stems from the unique position they have traditionally held in the Internet value chain conceptualized as a two sided market with content and application providers (CAPs) on one side and end users on the other with the TISP as a bottleneck monopoly in between them. See Figure 1 for details. According to the 'end to end design principle' espoused by net neutrality advocates, traffic on the Internet should be determined by decisions at the edges of the network with the TISPs playing the role of a ‘dumb pipe’.

![Figure 5-1. The Two-Sided Platform Model of TISP](image)

Clearly, a dominant TISP can hinder competition in a downstream market in a number of ways, including by exercising market power in pricing, or by vertical arrangements (either formal or informal) with content and application providers. For instance, a telco with its own marketplace for apps (such as iMode owned by DoCoMo), can increase barriers to entry for other application marketplaces that are not part of the ecosystem helmed by DoCoMo.
Unregulated TISPs may also have a tendency to extract all their revenues from Content and Application Providers (CAPs), as opposed to end users. This possibility arises because CAPs have no choice but to make themselves available via all telecom service providers, i.e. they are ‘multi-homing’. On the other hand, end users restrict themselves to one service provider, i.e. they are ‘single-homing’. Thus, TISPs have much greater pricing power over CAPs than over end users. This could lead to the CAPs bearing unsustainable costs.

Traffic management and pricing were believed to be the two dimensions along which TISPs could use their market power. Traffic management techniques allow connectivity providers to manage traffic more extensively, and to differentiate packet routing based on content, applications, and users. The practice of traffic management allows for a wide range of operations such as the construction of fast lanes for certain types of data, the provision of guaranteed network capacity for certain types of users, prevention of access to illegal content, and authentication of customers. These practices are contrary to the ‘best effort’ paradigm under which traffic was managed in the early days of the internet, and which early net neutrality advocates championed as the best way forward. As for discriminatory pricing, net neutrality advocates supported a ‘zero pricing’ world in which TISPs did not charge CAPs and obtained their revenues only from end users.

The reality with respect to adherence to net neutrality can be divided into 4 categories: Pure Net Neutrality, Differential Pricing with no Traffic management, Differentiated traffic management without Differential Pricing, and Pure Non Net Neutrality (see the Table below from Prasad & Sridhar, 2015).

Table 5-1. Dimensions of Net Neutrality

<table>
<thead>
<tr>
<th>Traffic management</th>
<th>Price discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Pure Net Neutrality</td>
<td>Differential Pricing</td>
</tr>
<tr>
<td>Differentiated traffic management</td>
<td>Pure Non Net Neutrality</td>
</tr>
</tbody>
</table>

As is obvious, the original conception of net neutrality was appropriate only for the early days of the internet. The outdated assumption that all innovation takes place within the CAPs and TISPs can only be ‘dumb’ pipes (hence not innovative), and the belief that that only TISPs could misuse gatekeeper functions are two fundamental pillars on which the original formulation of net neutrality rested. Both are questionable.
The TISPs opposed network neutrality regulations claiming that such regulations would discourage investment in broadband networks. The logic is that they would have no incentive to invest in network capacity unless content providers supporting bandwidth-intensive multimedia applications paid a premium for heavy Internet traffic. Such CAPs themselves would be adversely affected by the degradation of network quality that might result in a world of pure net neutrality.

It is no surprise that today, net neutrality in practice is vastly different from the original formulation. In a best effort network all end user service requests demanding network capacity are treated equally irrespective of nature or content. However, while best effort is the stated regime on the Internet, traffic management techniques that allow connectivity providers to manage traffic more extensively, and to differentiate packet routing based on content, applications, and commercial agreements have been increasingly in use ever since the inception of the internet. (Sridhar, Feb 2019) 7. Further, as highlighted below, a variety of commercial arrangements between CAPs and TISPs are now permissible under the paradigm of net neutrality.

Indeed, the current role of net neutrality has come a long way from the original conception of Tim Berners-Lee, Inventor of the World Wide Web and MIT Professor who said: “The neutral communications medium is essential to our society. It is the basis of a fair, competitive market economy. It is the basis of democracy, by which a community should decide what to do. It is the basis of science, by which humankind should decide what is true. Let us protect the neutrality of the net.”

5.2. Net Neutrality in India

India is seen as a global leader in mandating the neutrality of the internet. It rose to prominence in 2016 when TRAI had shutdown the 'zero rating' scheme under which internet service providers were planning to provide access to a select set of websites free of charge.

There have been a number of policy initiatives to define the country’s stance on net neutrality. A committee established by the DoT submitted recommendations in May 2015 (DOT 2015). The TRAI gave DoT its recommendations on net neutrality in November 2017(TRAI 2017). In 2018 the government came up with a regulatory framework on net neutrality and amended the terms of various license agreements to incorporate the principles of net neutrality along with appropriate exclusions and exceptions (DOT 2018). The broad contours of accepted regulatory understanding in India about net neutrality are as follows:

I. a licensee providing internet access service shall not engage in any discriminatory treatment of content including based on the sender or receiver, or the protocols being used for the user equipment.
II. the licensee is prohibited from entering into any arrangement, agreement or contract, by whatever name called, with any person natural or legal, that has the effect of

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7 Partly based on Consumer Unity & Trust Society (CUTS) International Washington DC Centre Policy Note #8 that was first published in February 2019 included with the permission of CUTS International.
discriminatory treatment”; however, reasonable traffic management practices are permissible.

According to TRAI (Nov 2017, p 23), Reasonable Traffic Management Practices are defined as follows:

“In general, TISPs have the incentives to ensure that their networks are managed in a manner that offers the best possible experience to a large number of users using different categories of content. However, the same commercial considerations that prompt TISPs to use traffic Management Practices (TMPs) to improve network performance can also become the cause of certain exclusionary or discriminatory practices. However, this should not in any way affect the ability of TISPs to manage their networks in a reasonable and efficient manner so as to optimise overall network performance and offer satisfactory quality of services to the users of a diverse variety of content.”

Further, the TISP is not restricted from the provision of specialized services that are not usable or offered as a replacement for internet access service and are not detrimental to the availability and overall quality of internet access service. Critical IOT services that are identified by the DOT which satisfy the definition of specialized services are also excluded from restrictions related to discriminatory treatment. However, IOT as a class of services are not excluded.

Content distribution networks are exempt from the scope of restrictions on non discriminatory treatment. While the potential of internet platforms to violate neutrality is acknowledged, and the issue of search neutrality is highlighted, no decision has been made relation of platforms or search engines as part of net neutrality directives.

While the original formulation of net neutrality envisaged a zero pricing rule, in the current global environment, including in India, the number of commercial arrangements between different entities in the Internet ecosystem has increased multi-fold. To understand the ramifications of these developments we have to understand that the internet value chain is no longer a two sided market.

5.3. New Value Chain

The conceptualization of net neutrality took place under the assumption of a two-sided network. However, the internet has evolved from its initial configuration. The current Internet value chain consists of many more types of entities and is graphically illustrated below.
In the above diagram, TISP provides the last mile access connectivity to the end user while CAP provides the content. The CAP is typically connected to a Content Delivery Network (CDN) through which the content provided by the CAP is routed to the TISP for distribution to the end user. The advertisers typically feed their advertisements in conjunction with the content provided by the CAP.

The commercial arrangements between different entities in the Internet ecosystem include contracts between CAPs and advertisers, CAPs and CDNs, CDNs and TISPs, CAPs and TISPs, CAPs and end users. The various charging mechanism between the above different stakeholders are given in the following Table:

<table>
<thead>
<tr>
<th>Charge</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Bandwidth charge paid by users to TISP</td>
</tr>
<tr>
<td>b</td>
<td>Charge paid by CAP to TISP for carrying their content to end users</td>
</tr>
<tr>
<td>c</td>
<td>Charge paid by CAP to CDN for routing their content to TISPs.</td>
</tr>
<tr>
<td>d</td>
<td>Content charge paid by the end user for the content/ application provided by the CAP</td>
</tr>
<tr>
<td>e</td>
<td>Charge paid by the TISP to CDN provider for carrying the traffic to their network</td>
</tr>
<tr>
<td>f</td>
<td>Charge paid by the advertisers to CAP for carrying their in-content ads and paid search returns</td>
</tr>
</tbody>
</table>

The changing hues of net neutrality have emerged in the context of new commercial and technical realities. The next section analyzes these trends.
5.3. Changing Commercial and Technical Realities

5.3.1. Increasing amounts of data, and increasing varieties of applications

The internet connectivity market has grown from zero to a multi-billion dollar market in fifteen years. The traffic conveyed on networks has also been increasing continuously. In 2016, worldwide IP traffic according to Cisco’s estimation stood at 96.1 exabytes per month. Peak internet traffic is estimated to have increased at a CAGR of 30% in the period of 2016-20. Mobile network data traffic itself is estimated to have doubled in the last two years to reach 118 EB per month by end of 2022. Worldwide mobile subscriptions currently stand at around 8.4 billion and is expected to rise to 9.2 billion by 2028 while fixed broadband subscriptions stand at 1.4 billion and is expected to reach 1.8 billion by 2028. These developments will place a heavy demand on IP networks. For instance, as per forecasts of Ericsson, total mobile network traffic is expected to grow at a CAGR of 26% and total fixed data traffic is expected to grow at a CAGR of 14% in the period of 2022-28. The increasing amounts of data means that CAPs, TISPs and other entities like CDNs, and cloud service providers need to cooperate to handle the traffic load.

Figure 5-3. Global IP traffic developments (fixed and mobile)
Source: Ericsson Mobility Reports (2022)

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12 ibid
A bulk of mobile data traffic is currently driven by video streaming (70%). However, with the rapid deployment of 5G, new and diverse internet applications with specific requirements are expected to emerge. For instance, critical IoT applications that demand data delivery within 50ms with 99.9 percent certainty. In this environment, classical injunctions of the net neutrality doctrine are increasingly obsolete.

![Mobile Traffic by Applications](image)

**Figure 5-4. Mobile traffic by applications**

Source: Ericsson (2022)

### 5.3.2. Increased power of CAPs

Over the past decade, the Internet has evolved to a point where many Internet companies also play gatekeeping roles, and enjoy significant market power. For instance, web search has become the starting point for virtually everyone to navigate the World Wide Web. By integrating search across text, image and video, Google search engine has a fair amount of control over what and how we access on the Internet. The original premise of net neutrality was that innovative CAPs needed to be protected from the market power of TISPs. Today, it is equally relevant to ask if they also need to be protected from the power of their fellow CAPs that enjoy disproportionate market power.

The principle of static efficiency asserts that market distortions would be minimized when the TISP loads its tariffs on to the side whose demand was less elastic, ie, the CAPs, rather than on the end user whose demand is very sensitive to price. This is because the CAP would not change its market behaviour as much as an end user following a higher charge on account of

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its relatively low sensitivity to price. Thus, the principle of *static* efficiency states that the TISP should collect a large part of its revenues from CAPs. This contradicts the stance of net neutrality that advocates charging the end user, not the CAP. The rationale for net neutrality emanates from the mandate of *dynamic* efficiency, i.e. the need to promote innovation in the internet by keeping barriers to entry low, i.e. by minimizing charges on the CAPs. The implication that dynamic efficiency is best promoted by protecting the CAP assumes that all technological innovation occurs within the CAPs and ignores the rapid developments that have radically transformed the provision of connectivity services. Further, it perpetuates the perception that all CAPs are ‘garage startups’ needing protection, ignoring the immense and increasing market power commanded by powerful CAPs in today’s world.

Recognizing the growing power of these CAPs, the EU Digital Markets Act seeks to ensure fair, transparent and contestable digital markets (EU, 2022). The Act is applicable to Core platform services offered by gatekeepers, which includes online search engines, social networking services, video sharing platforms, number independent interpersonal communications, operating systems, web browsers, online advertising, virtual assistants, cloud computing, etc. For an undertaking to be classified as gatekeeper, it has to have a significant impact on the market [annual turnover Euro 7.5 bn, MCap Euro 75 bn 45mn monthly active end users & 10000 business users] The Act lays down obligations for gatekeepers – which include:

a) Not to cross use personal data  
b) Not prevent business users from offering same products/services  
c) Enable end users to uninstall applications, change default settings, not treat itself more favourably, and not restrict choice of end users  
d) For number independent services – to be interoperable with other number independent services – free of charge – to publish a reference offer for the same  
e) Comply with cyber security, consumer protection, product safety, as well as with the accessibility requirements.

It can be seen that globally regulators and policy makers are distinguishing on the basis of size and additional obligations are (being imposed on entities above a defined threshold. The same approach has also been adopted in India where the Intermediary rules impose additional due diligence obligations on significant social media intermediaries. Vide gazette notification dated 25 February 2021, Central Government has specified fifty lakh registered users in India as the threshold for a social media intermediary to be considered a significant social media intermediary (MeITy, 2021).

### 5.4. Potential Synergies from Closer Collaboration Between CAPs and TISPs

The benefits/principles of classical net neutrality also have to be re-assessed in the light of new technical possibilities of 5G that require close integration between TISPs and CAPs, most importantly ‘network slicing’.
5.4.1. Network slicing and its effects on Net Neutrality

Traditional mobile communication networks employ the one-size-fits-all approach to providing services to mobile devices, regardless of the communication requirements of vertical services. This design philosophy can’t offer differentiated services. The concept of “network slicing” has been proposed to address the diversified service requirements in 5G with the advent of technologies such as Software Defined Network (SDN) and Network Function Virtualization (NFV). Network slicing is an end-to-end logical network provisioned with a set of isolated virtual resources on the shared physical infrastructure. These logical networks are provided as different services to fulfill users’ varying communication requirements. Network slicing provides a network-as-a-service (NaaS) model, flexibly allocating and reallocating resources according to dynamic demands, such that it can customize network slices for diverse and complex 5G communication scenarios (Lee, et al., 2017).

The technology of network slicing provides a compelling use case for constructing private networks. Private networks with associated Quality of Service requirements can be provisioned by creating network slices of adequate capacity, reliability and latency (Eswaran & Honnavalli, 2022), by the mobile network service provider. These slices can also be created at the network layer and procured by the private enterprises for constructing their own private networks. The complexity of managing network slices across different user requirements poses a challenge to both the network operator as well as ISPs ((Eswaran & Honnavalli, 2022). The requirements of the private network users can be fulfilled by the network providers/ ISPs using contractual agreements.

While net neutrality promoted innovation by reducing barriers to entry for new CAPs, vertical arrangements between TISPs, CDNs and CAPs can also promote innovation via better integration between different elements of the value chain. The presence of these complementarities has led to the phenomenon of ‘walled gardens’ comprising network operators, handset manufacturers, platform vendors, and content providers coming together to provide the entire suite of digital services and products.

In the amendments to the UL and UL(VNO) licenses, the DoT has specified the following with reference to “specialized services” as per TRAI’s recommendations on Net Neutrality (DoT, 26 Sep 2018):

“Nothing contained in this provision shall restrict:
   a) The provision of any Specialised Service by a Licensee, provided that:
      • The Specialised Services are not usable or offered as a replacement for Internet Access Service; and
      • The provision of the Specialised Services is not detrimental to the availability and overall quality of Internet Access Service”

From the above directive, it may be concluded that construction of private networks through network slicing contract between TISPs and CAPs can be construed as a “specialized service” as it does not act as a substitute for public Internet access service. However, the provisioning of such services shall not affect the QoS of the public Internet access service. Hence as long as TISPs maintain the broadband speed as mandated by the Government, the provisioning of such services shall not be considered as violation of net neutrality.
But as the list of exceptions increases, we have to ask ourselves at what point we must regard ourselves as having definitively moved away from the broad worldviews encompassed by the umbrella term ‘net neutrality’, and having entered a new reality.

5.5. Net Neutrality Policy Directives in a 5G World

In a 5G world, the most important tasks for advocates of net neutrality is to ensure QoS in the public network, and competitive markets in the provision of network slicing.

If not done properly, the construction of network slices for private networks could affect the capacity and reliability requirements of network capacity allocated for PLMNs. As a result, public users would be at a significant disadvantage. Further, the market for network slices could be distorted by the actions of influential CAPs. The following are the contours of the new approach that would address these challenges

1. Allocate enough capacity network slices for public network that guarantees the broadband requirements defined by the regulator. The objective should be to ensure good 4G-level connectivity. The current requirement in India is 2 Mbps downlink speed for an individual connection.

   The Body of European Regulators for Electronic Communication (BEREC) has developed a useful regulatory assessment methodology in order to provide guidance to National Regulatory Authorities (NRAs) with the implementation of the net neutrality provisions of the Regulation (BEREC, 2017). It is intended to help regulators in the monitoring and supervision of the net neutrality provisions of the Regulation based on various net neutrality measurement tools and harmonised measurement methodology for quality of service. According to the Regulation, TISPs must describe the minimum, normally available, maximum and advertised download and upload speed in their fixed network contracts. For mobile network subscriptions, TISPs must describe estimated maximum and advertised download and upload speeds. One of the important uses of TISPs disclosing the advertised service parameters and their subsequent measurement is to detect unreasonable Traffic Management Practices including throttling and traffic shaping of certain applications or content. Apart from TISPs submitting all the QoS parameters, third party tools are also available for detecting traffic prioritization as given in Sridhar (2019). Such a methodology can be used to monitor the performance of the public internet.

2. The contractual technical agreements for private network slices should be filed by the communication service providers periodically with the regulator to ensure that the mentioned QoS for public network slices as given in (1) are possible. If there are any anomalies detected, then the regulator can take remedial measures to address the same.

3. Since CDNs are not directly providing services to end users, they should not be made subject to Net Neutrality rules, including for any traffic prioritization at the behest of TISPs or CAPs.

4. The space of specialized services should be broadened to include the various possibilities that emerge with 5G technologies.
While net neutrality takes on new dimensions in a 5G world, the regulator cannot restrict themselves to ensuring fair access to the internet for CAPs and end users. As mentioned before, many CAPs have become essential gatekeepers on the internet and acquired significant market power. Hence, the spirit of net neutrality has to be extended to the digital ecosystem as a whole.

5.6. Digital Neutrality

Digital neutrality is a new approach to achieving the objectives that were implicit in the doctrine of net neutrality. It recognizes that CAPs are not the only engines of innovation, and that TISPs too play an important role in creating the next generation of transformative developments. Further, it acknowledges that the barriers to innovation on the Internet can also stem from large CAPs that potentially serve as gatekeepers on the Internet, and whose vertically integrated structures potentially created conflicts of interest that could be harmful to competition.

Digital neutrality focuses on creating fair competition in all parts of the digital ecosystem including search, e-commerce, and social networks, not merely in the provision of connectivity. In particular, it is concerned with the regulation of vertical mergers and other vertical commercial arrangements that could inhibit competition, while recognising that such arrangements may potentially also lead to increase efficiencies. The genesis of net neutrality lay in competition regulation and ensuring fair and competitive markets. This tenet must continue on how net neutrality is implemented.

The recent case the bundling of payments associated with Google apps with the Google payment system is an example of the kind of vertical arrangements that could potentially distort the neutrality of the digital eco system and should be in the purview of the regulator. The tieups between search engines and comparison shopping services are other arrangements whose benefits and harms need to be assessed. Indeed, the issue of search neutrality is a central concern of the paradigm of digital neutrality.

Timothy Wu, the person who coined the definition of net neutrality, advocates the “Separations Principle” that creates salutatory distance between each of the many layers of the information economy. While separation should be examined on a case-by-case basis, the writing on the wall is clear: It is time to conceive of neutrality afresh in the context of vastly transformed business and technological possibilities. We need neutrality at the level of the digital economy, not just at the level of the provision of connectivity services.

5.7. Conclusions

This chapter proposes a new approach—digital neutrality – to replace net neutrality, and bases the recommendation on new technological and business developments in the digital sphere. The following points are highlighted:

1) Transition to a new regulatory approach - Digital neutrality - that recognizes that TISPs as much as CAPs play an important role in creating the next generation of innovations,
and that large CAPs as much as TISPs serve as gatekeepers on the internet. Digital neutrality focuses on creating fair competition in all parts of the digital ecosystem including search, e-commerce, and social networks, not merely in the provision of connectivity. Search neutrality is an important part of the new approach.

2) Bring in the concept of significant CAPs to apply additional obligations
3) Allocate enough capacity network slices for public network that guarantees 4G-level connectivity.
4) Ensure competitive markets in the provision of network slicing.
5) CDNs should not be made subject to Net Neutrality rules.
6) The space of specialized services should be broadened to include the various possibilities that emerge with 5G technologies.

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Chapter 6. Interconnection and Data Portability Regulation

Abstract

Interconnection is one of the important characteristics that facilitates the network effects of the telecom industry. Interconnection between networks using standardized technical interfaces enables telephone calls to originate and terminate across networks spanning geographies and service providers. However, the level and mode of determination of charges levied for traffic that spans across networks is a contentious issue. Further, with technologies enabling VoIP and Internet Telephony, calls span across the Internet and the traditional telecom networks (e.g. PSTN/PLMN). Though the technical interfaces have been standardized, there are commercial issues on interconnection that need to be addressed with regulatory guidance.

This chapter provides a taxonomy of interconnection charges and discusses the different types of charges, especially the mobile termination charges. The chapter also highlights whether the technical and financial aspects of interconnection regulation should be applicable for OTT communication providers as well.

6.1. Taxonomy of Interconnection charges

Telecom networks while benefitting from intrinsic direct network effects depend on interconnection and interoperability for scaling up. In the absence of interconnection regulation obligation, virtually every telephone market in the early twentieth century in the US and rest of the world became monopolies with a single largest network to which everyone needed to connect. The potential for certain industries such as telecom to move toward a monopoly structure in this manner illustrates the economic implications of interconnecting networks (Nuechterlein & Weiser, 2005). Interconnection usage charge (IUC) is the charge payable by a service provider to other service provider or service providers for the usage of the network elements for transit or termination of the calls (Sridhar, 2012).

Interconnection of networks can happen at various levels and is illustrated in the following Figure.

Figure 6-1. Call flow across LSA within a country

Source: Sridhar (2019)
In the above figure, calls that originate from a landline or mobile after passing through the originating Access Service Provider (ASP) are handed over to the National Long Distance Operator (NLDO) at the Point of Presence (PoP). The NLDO carries the calls across the LSAs and hand them over to the terminating ASPs at the termination service areas which in turn terminate the call on a landline/ mobile. In case of calls, within the LSA, the calls are handed over by the originating ASP to the terminating ASP directly. The Interconnection Usage Charges (IUC) are the charges paid by the originating ASP to the NLDO and terminating ASP for carrying the calls through their networks.

The following Figure illustrates the origination to termination of an international call.

![Figure 6-2. Call flow of an International call](Source: Sridhar (2019))

The flow of an international call is very similar to domestic call except that it passes through a foreign carrier who hands over the call to International Long Distance Operator (ILDO) who then further hands over the call to NLDO towards termination. The compensation paid by the foreign carrier to domestic ASP is referred to as in the international settlement charges.

### 6.2. Termination Charges

Initially, the mobile operators had a receiving party pays regime that was changed to Calling Party Pays scheme in 1999. Subsequently, the Reference Interconnect Order of TRAI in July 2002 specified interconnection charges to be mutually agreed upon between network operators (TRAI, 2002). However, most of the operators could not come to mutual agreements on network interconnection charges.

Given this impasse, the need was felt for an interconnection regulation that facilitated a level-playing-field for all operators, provided equitable revenue-sharing terms, and allowed open interconnectivity, so that subscribers could make any type of inter-network calls. To address these issues and facilitate equitable interconnection terms, in January 2003 TRAI issued the interconnection regulation with respect to cost-based interconnection usage charges for inter network calls. On May 1, 2003, the Telecommunication Interconnection Usage Charges (IUC) regulation notified by TRAI came into existence (TRAI, 2003).

Termination of calls assumes prominence when there are a number of telecom access providers. Call termination results in externalities – both positive and negative. Since the origination and termination of calls need not be on the same network (also referred to as off-
termination service provider acts as a monopoly bottleneck facility to the originating call. While successful termination results in positive network externality, denial of the same results in negative effect. The denial of termination could be due to technical or economic reasons. The negative externality in call termination has the effect of reducing competition and poor quality of service. One way to circumvent this failure is through regulatory intervention (Sridhar, 27 Mar 2006).

In general, calls terminated within caller’s networks (referred to as on-net calls) are often charged less than off-net (i.e. terminating on a different operator’s network) calls. One reason for this is the termination charge to be paid to the receiver’s network for off-net calls. This fixed termination charge if set high will increase the user charges; and reduce welfare of consumers who make off-net calls. High termination charges will also lead to originating service providers’ reluctance to interconnect with other operators. If set low, it will lead to operators resorting to practices of denial of call terminations originating from other networks (Sridhar, 2012). The cost associated with termination of off-net calls is higher than for on-net calls as the originating service provider needs to provide enough bandwidth at the Point of Interconnect to the terminating provider and is discussed in the subsequent section.

Mobile service providers have contended that the termination charges in India are below cost and amongst the lowest in the world. Even TRAI noted that mobile termination charges are 12-14 times lower than that prevailing in other countries (TRAI, 2006). This leads to possible refusal of termination of calls or inadequate provisioning of interconnections with other networks for termination facilities. The theoretical literature on termination rates indicate that mobile operators have an incentive to set termination charges that help them extract maximum surplus. Low termination rates, on the contrary might even force the operators to increase price and raise subscription charges, which is referred to as “water bed effect” (Genakos & Valletti, 2007). In general, the larger operators propose higher termination charges as the expected number of incoming calls from smaller networks are more than outgoing calls to such networks. For the same reason, the smaller entrants lobby for lower MTC.

The following Table indicates the revision in termination charges – both domestic and international over time (TRAI, 2018). In its 2018 order, TRAI reduced the Mobile Termination Charges (MTC) which is the charges paid by the originating ASP to terminating mobile networks for domestic calls to 6 paisa/min in 2018. The MTC was subsequently reduced to zero for all domestic calls with effect from January 2020 (TRAI, Dec 2019). The MTC for international incoming calls stay at 0.53 paisa/ min.

Regulators tend to fix the floor charges for mobile termination enough to cover the marginal cost of termination. The argument for lowering the termination charges over time is the introduction of emerging technologies that have reduced the termination costs. Further, marginal cost of termination on a wireline in general is very low due to higher capacities and associated fixed costs of wireline infrastructure. It is important to note that when there is a symmetry of call volumes between any two operators, then MTC has no relevance. In fact the Regulator’s decision to make termination charges nil, was premised on the basis of symmetric traffic between networks.
Table 6-1. Revision of Termination Charges by TRAI

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Period</th>
<th>Domestic Mobile Termination Charges (wireless to wireless)</th>
<th>International Termination Charge (terminating on wireline or wireless)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
<td>To</td>
<td>INR./Min</td>
</tr>
<tr>
<td>1</td>
<td>01.05.2003</td>
<td>31.01.2004</td>
<td>0.15-0.50</td>
</tr>
<tr>
<td>2</td>
<td>01.02.2004</td>
<td>31.01.2005</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>01.02.2005</td>
<td>28.02.2006</td>
<td>0.3</td>
</tr>
<tr>
<td>4</td>
<td>01.03.2006</td>
<td>31.03.2007</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>01.04.2007</td>
<td>31.03.2008</td>
<td>0.3</td>
</tr>
<tr>
<td>6</td>
<td>01.04.2008</td>
<td>30.09.2008</td>
<td>0.3</td>
</tr>
<tr>
<td>7</td>
<td>01.10.2008</td>
<td>31.03.2009</td>
<td>0.3</td>
</tr>
<tr>
<td>8</td>
<td>01.04.2009</td>
<td>28.02.2015</td>
<td>0.2</td>
</tr>
<tr>
<td>9</td>
<td>01.03.2015</td>
<td>30.09.2017</td>
<td>0.14</td>
</tr>
<tr>
<td>10</td>
<td>01.10.2017</td>
<td>12.01.2018</td>
<td>0.06</td>
</tr>
<tr>
<td>11</td>
<td>01.02.2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>17.12.2019</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>13</td>
<td>01.05.2020</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.3. Interconnect Congestion

Associated with termination charges are the interconnect infrastructure to be deployed by the TSPs at the Points of Interconnect (Pols). If the termination charges are kept too low, the terminating TSP which is in fact monopoly service provider for that call that needs to be terminated may use its bottleneck termination facility to block or slower the termination. The insufficient provisioning of telecom circuit resources depending on traffic requirements at the Pols leads to:

i. Intra and inter-network congestion at the Point of Interconnection (POI);
ii. loss of calls;
iii. repeated call attempts by consumers;
iv. deterioration in Quality of Service (QoS) and resultant consumer dissatisfaction.

Hence, unless traffic symmetry is reached across the operators, the termination charges and associated Pol congestion continue to be a debatable regulatory issue (for details on the regulatory literature on IUC with specific reference to India, refer to Kedia, 2018). While initially, the traffic symmetry between the telcos broadly justified Bill & Keep regime, the recent emergence of Internet telephony only players seeking to terminate their calls on mobile networks, calls for a review of the current zero termination charges regime.
6.4. Interconnection charges for IP based calls

While the Internet Usage Charges regime is applicable for PSTN/PLMN calls, traffic is shifting away from PSTN/PLMN to packet switched IP calls. One of the common forms of these types of calls are the Internet telephony calls made from OTT communication apps, such as Skype, WhatsApp. There are also now cases of OTT Communication players taking an access service authorization to offer Internet telephony calls. We discuss in this section, the applicability of IUC, in particular, the MTC for such types of calls.

6.4.1. Internet telephony calls terminating on Carrier Network

The Internet telephony calls that terminate on PLMN evoke special interest to regulators. Figure 6-3 provides the schematics of the Internet telephony calls terminating on PSTN/PLMN. When the user makes this type of call, it is difficult to determine the exact location of the origination of the call (e.g. location of the Internet Telephony app, location of the gateway that translates the Internet Telephony call to PLMN call). Hence the Internet firms argue that it is not possible to bring it under interconnection regulation. However, the mobile operators argue for termination charges as they incur marginal cost in termination.

On April 1, 2002, India allowed a restricted form of Internet Telephony, in which the IP device to IP device communication was allowed. However, termination on PSTN/PLMN was disallowed (Sridhar, 2012). One way by which the DoT had enforced this restricted form was to ban the deployment of Media Gateway Switch that interconnects and translates packet switched traffic to equivalent circuit switched services within India. It is ironical that permission for a call originating from IP device to terminate in a PLMN/PSTN device outside India had to be granted as Indian government and regulator do not have jurisdiction over the installation of media gateway switch that interconnects an IP call to a PSTN/PLMN call outside India.

TRAI recommended relaxing the restricted form, first for the licensed telcos in 2006 and DoT modified the license conditions for both wireline and wireless access services providers. Subsequently the following clause is retained in the Unified License with Access Service authorization (DoT, 2013):

"While providing Internet Telephony service, the Licensee may interconnect Internet Telephony network with PSTN/PLMN/GMPCS network."

Subsequently in 2016, the DoT issued modifications to the Unified Access Service Licensees as well Unified Licensees with Access Service authorization allowing deployment of Media Gateway Switch within India for interconnecting the Internet and PSTN/PLMN for facilitating flow of Internet Telephony calls from outside India to the carrier network (DoT, 19 April 2016).
The clause in the Unified License with Internet Service authorization in Chapter IX reads as follows (DoT, 2013, p 64):

“The Licensee (UL with Internet Service authorization) may provide Internet Telephony through Public Internet by the use of Personal Computers (PC) or IP based Customer Premises Equipment (CPE) connecting only the following:

a) PC to PC; within or outside India
b) PC / a device / Adapter conforming to TEC or International Standard in India to PSTN/PLMN abroad.
c) Any device / Adapter conforming to TEC or International Standard connected to ISP node with static IP address to similar device / Adapter; within or outside India.

Explanation: Internet Telephony is a different service in its scope, nature and kind from real time voice service as offered by other licensees like Basic Service Licensees, Cellular Mobile Telephone Service (CMTS) Licensees, Unified Access Service (UAS) Licensees, Unified Licensee (Access Service), Unified Licensee with authorization for access services. The Internet Telephony, only as described in condition (ii) above, can be provided by the Licensee. Voice communication to and from a telephone connected to PSTN/PLMN/GMPCS and use of E.164 numbering is prohibited.”

The above clause rules out provisioning of unrestricted Internet Telephony by pure play ISPs as well as any of the App based providers such as Skype or Hike to connect Internet Telephony calls to PSTN/PLMN networks.

6.4.2. International Internet telephony calls terminating on local Carrier Network

The following diagram shows how an International call originating in Skype or any other Internet Telephony app from a foreign country can be terminated in India on a PLMN/PSTN. The call necessarily has to be handed over by the ISP to ILDO who in turn routes the call towards the destination. In order for a call to be terminated onto PSTN/PLMN; the call will need to be delivered to the relevant carrier at its POI in the requisite form. This means that the call will need to be converted from a packet switched Internet call to a standard circuit switched call along with CCS#7 signaling process, before it is routed to the POI of the mobile or fixed carrier. Further, the IP address of the origin and destination as present in the Internet Telephony call needs to be translated in to corresponding E.164 international numbering.
format before termination. This is normally done by the media gateway switch using ENUM translation scheme (refer to the glossary for details on ENUM standard).

For the above type of Internet telephony calls that originate outside the country, but terminating in carrier network within India, should the termination charges be applicable as per IUC?

Realizing these issues, TRAI in its recommendation has indicated the following (TRAI, 2017, p 47):

“The call termination charge for VoIP calls terminated onto a mobile or fixed line network would be the same as calls made from traditional services”.

Further, DoT (2017), p 56 states the following:

“Internet Telephony calls originated by International out roammers from international locations should be handed over at the International gateway of licensed ILDOs and International termination charges should be paid to the terminating access service provider.”

Hence for international calls that terminate on PSTN/PLMN, the same international termination charges shall apply.

However despite these regulations, a grey market for international Internet telephony calls still exists. In this, the Internet telephony calls that originate from outside the country are masqueraded as local calls and terminated on the local carrier network, thereby incurring zero (as of now) MTC compared to the higher MTC as levied for the international calls. The TRAI has been periodically alerting consumers of these types of calls and requesting consumers to inform, if the caller IDs for the incoming calls are not shown. Details of the grey market operation for evading international termination charges are provided in Sridhar (2019).

![Image of Schematic diagram of International Internet Telephony call flow](source:Sridhar (2019))

Figure 6-4. Schematic diagram of International Internet Telephony call flow
6.4.3. Recent regulation on interconnection of Internet Telephony

In 2017, TRAI after extensive consultation on Internet Telephony issued recommendations on a host of issues including numbering scheme to be used, ENUM implementation, enabling monitoring of calls by law enforcement officials and so on (TRAI, 2017).

As per the DoT (19 June 2018) amendment, mobile numbering series is to be used for provision of Internet Telephony calls and further that the said service is untethered from the underlying access network. Realizing this opportunity to interconnect with PSTN/PLMN network, many VoIP communication service providers such as Ring Central, Zoom, Cisco Webex have applied, for UL with Access Service authorization (DoT, 31 Dec 2022) for providing enhanced VoIP services that connect to PSTN/PLMN. Similar amendment was also carried out in the UL (VNO) License.

In light of the modification of license conditions regarding Internet Telephony and given the fact that the termination is on a PSTN/PLMN that has costs associated with last mile termination, the current regime of zero termination charges require a review especially if there is significant asymmetry of traffic between the OTT apps and PSTN/PLMN. Hence, a study needs to be conducted on the proportion of Internet Telephony calls that terminate on the PSTN/PLMN networks for the possible revisions of termination charges.

Question often arises as to how Internet Telephony calls or OTT calls that originate over the Internet untethered from the underlying carrier network can be subject to a termination charge. Once the Internet telephony calls interconnect with a carrier network, the underlying paradigm of “untethered” does not hold as the termination becomes carrier dependent. Hence the logic of non-applicability of termination charges does not hold true.

6.5. Interconnection between OTT Communication Apps

While the interconnection of carrier networks have been mandated by the regulators, the interconnection between OTT communication apps evaded regulatory scrutiny. In view of the functional separation principle as outlined in Chapter 4. As OTT communication apps are increasingly becoming the most widely used, the regulation should also actively be pursued over the interconnection of various OTT apps so that messages from one app could be sent or received from another app.

The OTT communication app providers have so far leveraged network effect to amass huge subscriber base. The large incumbent OTT communication players have little incentive to interconnect with smaller apps. However, the new entrants in the OTT communication space, can sustain only if they are allowed to interconnect with larger incumbents apps. Hence, much the same way, the interconnection regulation mandated the interconnection of carrier networks, the same shall be applicable for OTT communication providers as well.

Interconnection of OTT communication apps are possible due to the incorporation of public Application Programme Interfaces (APIs). Using APIs, it is possible to communicate across OTT apps much the same way the email communication across service providers are possible using the Email addressing scheme and the Simple Mail Transfer Protocol (SMTP). Contrary
to what the incumbents claim, the network effect and associated benefits will accrue to both
the incumbents and new entrants if the internetworking is enabled as above.

6.5.1. Evolving communication technologies for Internetworking

The gold standard for interoperable messaging systems is Extensible Messaging and
Presence Protocol (XMPP) - a set of open technologies for instant messaging, presence,
multi-party chat, voice and video calls, collaboration, lightweight middleware, content
syndication, and generalized routing of eXtensible Markup Language (XML) data (XMPP,
2023). Originally developed by the Jabber open community, XMPP is the core protocol that
powers today’s OTT communication apps including WhatsApp, and Google Chat. There are
a number of XMPP client apps available such as Dino and Swift.IM for desktops; blabber.im
and Quicksy for Android mobiles; Monal and Siskin IM for iOS mobiles. The large OTT
communication apps such as WhatsApp modified the XMPP considerably to improve
performance and usability. However, these modified versions have also been converted in to
closed systems thereby preventing interoperability with similar XMPP based apps. An
indigenous app called “Prav” is being developed by a group of Indian tech volunteers that is
not vendor locked and has all the richness offered by XMPP (Prav, 2023).

The WebRTC (Web Real Time Communication), is the standard of which has been drafted
by the World Wide Web Consortium (W3C) that also uses the SMPP framework. The
technology allows Peer-to-Peer (P2P) multimedia communication from one Internet user to
another over simple Web browsers, via simple “non-proprietary” Javascript Application
Programme Interfaces (API) or the open HTML 5. WebRTC enables users to initiate a voice/
video call directly from their mobile / laptop Web browsers without the need for any external
native software application such as Skype or WhatsApp (Panda & Sridhar, 2016). WebRTC offers web application developers the ability to write rich, real-time multimedia applications on
the web, without requiring plug-ins, downloads or installs. The WebRTC was initiated by
Google for inclusion in its Chrome browsers; however, after the adoption by W3C, it has
come a widely accepted standard for inclusion in all web browsers. The unique aspect of
this communication technology is that it does not require any centralized service to connect
the origin and destination and in its purest P2P form. Thus it enables communication without
even a simple directory service provided by intermediaries. The technology consists of three
major APIs which can be called from a variety of programming languages for accessing
multimedia resources; for initiating peer-to-peer connection; and to enable data sharing across
the connected parties.

While technologies such as these continue to evolve and hence provide options for
internetworking and interoperability, there are not adopted beyond small groups due to lack of
network effect that the significant OTT apps have. Due to non-internetworking and non-
interoperability between these and significant OTT apps, the benefits of the open protocol do
not reach the end users. Much like in a telecom network, the larger networks do not benefit
from inter-networking and hence the significant OTT apps have built their walled garden to
preserve their monopoly power over their users. It is time that regulators shall intervene to
promote internetworking of OTT apps for the benefit of users.
6.6. Access to Emergency Services

The facility to call nearest authority like police, fire station, hospital, etc has been termed as access to Emergency Service. Accurate identification of geographical location of subscriber is a must for availing emergency services. The concept of emergency number calling has changed with introduction of the mobile services. It is envisaged that accurate location of the caller will also be available to the authority handling emergency situation along with emergency number calls. The Telecom Service Providers use different technologies to provide location services, depending on whether the call originates in a fixed landline or mobile. TRAI in its consultation on Internet Telephony regulation invited comments from various stakeholders on whether such emergency calling service is possible in the case of Internet Telephony service. Based on the responses, TRAI recommended that that the UL/UL(VNO) licensees that provide Internet Telephony service may be encouraged to facilitate access to emergency number calls using location services; however they may not be mandated to provide such services at present (TRAI, 2017). However, it also stated that the subscribers may be informed about the limitations of providing access to emergency services to Internet Telephony subscribers in unambiguous terms. The same was included in the DoT UL amendments. However, the VNOs were mandated to provide the emergency services through their respective parent TSP (DoT, 31 Aug 2018).

However, with the ubiquitous use of Internet Telephony services including OTT apps for communication, many countries have mandated the provisioning of emergency service by the Internet Telephony service providers. Ofcom in its Regulatory Impact Assessment conducted in 2007 has clearly indicated the benefits of mandating emergency calling service be enabled for Voice Over IP calls (Ofcom, 2007). Along the same lines, it is recommended that both VNOs who provide Internet Telephony services and OTT communication service providers shall be mandated to provide emergency calling services, facilitated by the interconnection with PSTN/PLMN networks.

In summary, following table provides the extant regulation on interconnection and emergency services:

<table>
<thead>
<tr>
<th>License Type</th>
<th>Interconnection Across PSTN/PLMN</th>
<th>Between Internet Telephony PSTN/PLMN</th>
<th>Across Internet Telephony</th>
<th>Emergency Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL with Access Service Authorization</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓ TRAI recommends Internet Telephony Providers also to provide</td>
</tr>
<tr>
<td>UL (VNO) with Access Service Authorization</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓ TRAI recommends Internet Telephony Providers to provide</td>
</tr>
</tbody>
</table>

Table 6-2. Existing regulation on Interconnection and emergency services
6.7. Number and Data Portability

6.7.1. Number portability

In telecom markets where there is enough competition, it is important to provide subscribers enough choice. Mobile Number Portability (MNP) allows the subscriber to retain their existing mobile number when they switch from one service provider to another or from one technology (GSM/CDMA) to another of the same service provider. Portability benefits subscribers and increases the level of competition between service providers, rewarding those operators having better customer service, network coverage, and service quality. Keeping in view the growth of telecom services in India, and the level of competition TRAI released its recommendations for MNP in 2006 so as to further enhance competition among service providers in the mobile sector and also to improve quality of service and satisfaction of the mobile subscribers (TRAI, Mar 2006).

As per the recommendations, MNP was initiated by the Indian government through neutral third party who shall establish logically centralised database for implementing the MNP database (DoT, 2008). For the purpose of MNP, the telecom service areas of the country was divided in to 2 zones with 11 service areas each with 2 metros in each area. Two third-party agencies were selected to provide the MNP service in the two zones. As per the MNP rules, in multi-operator scenario when N operators are involved in the complete call setup considering 1 being the originating operator and N being Terminating operator, (N-1)th operator shall be responsible for routing the call to ported numbers. The up-gradation cost of their network will be borne by the operators themselves. The Recipient operator shall be permitted to charge a fee for successful porting directly to subscribers (for details on MNP, refer to Sridhar, 2012).

The numbering allotment in case of Virtual Network Operator (VNO) is provided in DoT (2016). The parent network operator shall allocate the numbering plan to the VNO. The mobile services customers of the VNO can port their mobile numbers, using MNP facility, to the service providers of their choice. These provisions shall be built-in as mandatory provisions in the commercial agreement between the NSO and the VNO.

6.7.2. Data portability
At this juncture, it is worth looking at developments in OTT communication which has not been addressed by the regulators and policy makers. The equivalent of mobile number in OTT communication is the IP address and TCP/IP socket address in which the OTT apps operate. Both of these are dynamically allocated and hence the number or address portability does not make sense in OTT communication. On the other hand, if an OTT communication subscriber intends to migrate from one app to another app, then there is a need to port all the contacts and related information pertaining to the subscriber from the current app to the new app. This is the close equivalent to number portability.

Article 20 of the European Union General Data Protection Regulation (EU GDPR) endows the data subjects with rights to data portability (EU, 2016). As per the clause, the data subjects can enforce her rights to port data from the current data controller/ data fiduciary to another data controller/ data fiduciary, without hindrance from the controller to which the personal data have been provided. Unfortunately, the Digital Personal Data Protection Bill 2022 does not have this clause (MeiTY, 2022). Hence in the interest of consumers, the data portability across OTT communication providers shall be enforced.

6.8. Conclusions

Interconnection, interoperability and portability are measures that provide choices for the consumers and prevent lock-in effect. The interconnection and the interoperability through standardized interfaces have been in existence for telecom networks. However, these are new areas for the regulation of OTT communications. Our recommendations are as follows:

1. The network providers shall facilitate the set up of media gateways of adequate capacity for the interconnection of Internet Telephony services with carrier networks.
2. The significant OTT communication providers shall be mandated to connect with the carrier networks, similar to VNOs.
3. The current domestic MTC regulation of Bill & Keep needs to be reviewed given the likely asymmetries in the traffic flows between OTT apps and PSTN/PLMN.
4. The international MTC for calls originating in OTT communication apps terminating on PSTN/PLMN in India shall be as per the existing MTC regulations.
5. For the VNOs, the existing regulations on numbering schemes and number portability are applicable.
6. The OTT communication providers shall enable interconnection with other OTT communication apps through open protocols such as XMPP, much the same way internetworking is mandated for carrier networks.
7. The significant OTT communication providers shall be mandated to provide emergency calling service much like the VNOs.
8. The significant OTT communication providers shall provide subscriber data portability, similar to number portability as mandated for carrier communication, to enable consumers to port from one OTT communication app to another.

Summary of our recommendations is given in the following Table:
Table 6-3. Proposed regulation on Interconnection and emergency services

<table>
<thead>
<tr>
<th>License Type</th>
<th>Interconnection</th>
<th>Emergency Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Across PSTN/PLMN</td>
<td>Between Internet Telephony PSTN/PLMN &lt;-&gt; Across Internet Telephony services</td>
</tr>
<tr>
<td>VNOs</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>OTT Communication Service Providers</td>
<td>×</td>
<td>✓</td>
</tr>
</tbody>
</table>

References


Chapter 7. Universal Service Policy

7.1. Introduction

Universal service refers to the provisioning of service – in this case telephony and broadband – to all areas including rural and remote areas, and to all demographics including low income households. The costs of such services are often partially compensated through a special corpus funded by carriers and by the government.

A Universal Service Policy is dynamic by its very nature. Shifts in technology, markets, and business constantly render extant policies obsolete. Traditionally, universal service referred to basic telephony, but newer services started getting introduced with technological advances, especially after the advent of digitalization (Jayakar & Sawhney 2004). In India, mobile services were included within the ambit of the USO in 2006, and broadband in 2009 (Jain & Raghuram 2010).

There are three important questions with regard to Universal services policy:

i. how should this policy be funded?
ii. what services should be subsidized?
iii. what mechanism should be used for disbursement of funds?

7.2. Universal Services Levy

In most countries, rural coverage and universal service provisioning is a licensing requirement for basic fixed line service providers. The Government of India as part of the National Telecom Policy 1999 created the Universal Service Obligation Fund (USOF) by charging Universal Service Levy (USL) at a prescribed percentage of the revenue (5% of the Adjusted Gross Revenue) earned by the operators holding different type of licenses (Sridhar, 2012). Consequently, the universal service obligation was removed from license terms, although certain rollout obligations were retained.

The universal services levy reflects the belief that telecom licensees needed to give back to society for the privilege of being chosen to provide telecom services, without being burdened with a universal service obligation in unviable areas. This approach implies that services in under-served areas are being subsidized by network operators and customers in viable markets.

7.3. Uses of the Universal Service Levy

Over time, the USOF fund has grown in size as illustrated in the Figure below (USOF, 2022):
Figure 7-1. Growth of USOF in India over the years (Fund status in Rs. Cr.)
Source: USOF (2022) as on 31 Dec 2022

The following chart gives an idea of how the USOF is currently being distributed across service schemes:

Figure 7-2. Stream wise distribution of USOF
Source: USOF (2018)

A brief review indicates the following trends:

i. Share of USOF distributed for Village Public Telephones has decreased considerably indicating the decreasing role of shared telecom services and increasing trend of personalized communication services such as household and mobile telephony;

ii. Substantial portion of USOF is distributed for the creation of general telecom infrastructure in rural and remote areas of the country;
iii. Significant portion of USOF is also allotted for new telecom initiatives such as green telecom.

Since large amount of USOF is being distributed for general telecom infrastructure, an explanation of the same is in order. The GoI initiated a nationwide optic fibre network christened “Bharat Net” with an objective to connect all the 250,000 village panchayat’s in the country through optic fibre backbone.

Following are the salient features of the project (BBNL, 2018):
   i. Panchayats in the country will be provided with 100 Mbps broadband connectivity;
   ii. Non-discriminatory access to the network will be provided to all the telecom service providers for providing access services;
   iii. The access providers such as mobile operators, Internet Service Providers (ISPs), Cable TV operators, content providers can launch various services in rural areas by connecting to BharathNet for their backhaul;
   iv. Various applications for e-health, e-education, e-governance etc. will be provided through this infrastructure;

The project is being executed by a Special Purpose Vehicle (SPV) - Bharat Broadband Network Limited (BBNL).

As we design a universal service scheme for 5G and beyond, we need to revisit the fundamental principles behind the concept of universal service.

7.4. Theoretical Issues: What to Build

There is growing literature on theoretical frameworks for choosing the services to be included in USO schemes14. In line with the canonical literature on the role of the state in economic theory, Gasmi and Virto (Gasmi and Virto 2005) discuss the role of the USO in terms of the 'market efficiency gap' and the 'viability gap'. The market efficiency gap refers to bottlenecks in the free working of the market mechanism that once removed would enable a particular service to be provided without further intervention by the USO organization. Examples include high usage charges on spectrum, high interconnection charges and discriminatory access to the local loop. A viability gap on the other hand refers to a situation where the provision of a service is beyond the ability of the market, even when allowed to function in the most optimal way.

A market efficiency gap requires the easing of bottlenecks in the working of markets and does not call for a universal service policy. Even a viability gap in itself is not a sufficient condition for the utilization of USO funds. Sawhney (Sawhney 2003) introduces two further criteria: first, a new communication technology should be provided on a universal basis once it becomes a

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14 In addition to the choice of services, one must also decide the level at which a service is to be provided. The concepts of universal service (US) and universal access (UA) to telecommunications and information and communication technology are distinct. US refers to service at the individual or household level, e.g. a telephone in each home. UA refers to a publicly shared level of service, e.g., through public payphones or Internet telecentres. However, they are also intrinsically linked to each other, as UA is the pre-cursor for US.
‘consumption norm’, since citizens cannot function effectively without it. Second, universalization of a service becomes a necessity if the lack thereof creates impediments and roadblocks at a systemic level.

The notion of a consumption norm goes back to the work of Adam Smith and refers to the bare essentials required by the poorest citizen to function in a society. The philosopher John Rawls refers to these as ‘primary goods’ (Rawls 1971). Reflecting the spirit of the consumption norm, the EU Universal Service Directive of 2002 (European Parliament 2002) identifies the following necessary condition for a service to be included within the ambit of universal service: ‘in the light of social, economic and technological developments, has the ability to use the service become critical for social inclusion?’

Some governments have tried to operationalize the notion by setting a trigger mechanism in the form of a minimum number of users that would need to be crossed before provision of subsidies for its universalization is considered. As cited by Sawhney (2003), the Californian Assembly Bill 3643, which became a law on January 1, 1995 set the threshold at 65% penetration of residential market (Commission 1996). In line with this approach, in the same year the EU decided not to expand the definition of USO to broadband citing the low levels of uptake in the society at large.

The second criterion identified by Sawhney is related to the system-centric forces that necessitate the inclusion of a particular service. For example, the development of factory production accelerated the movement for universal education in the nineteenth century as factory owners needed educated workers (Sawhney 2003). Similarly, accelerated globalization and the attendant cross-border travel led to a standardization of the training of airplane pilots in the early nineteen nineties. In the area of telecommunications, the need for nationwide systems for governance, service delivery, and commerce is creating pressure for the development of digital infrastructure in rural areas.

Prasad (2013) introduces ‘temporality’ as a third criterion for choice of services. Temporality refers to the time taken in building out an ICT network. If an ICT network takes time to build then it makes sense to start the process in advance of the service becoming a consumption norm or system requirement.

Based on these criteria we identify two-pronged strategy for services to be funded by a universal service levy:

1) 4G for all, and
2) Fiberization of towers for 5G in urban and semi-urban areas.

7.4.1. Good 4G: A Consumption Norm

The current Internet penetration of the country is about 48%. This does not qualify broadband to become a consumption norm that needs to be guaranteed through government support. From a systemic point of view, however, the usefulness of broadband cannot be denied. Even if it has to be weighed against the usefulness of other systemic inputs like education, and health, we must recall broadband can be an enabler for universal health and education through
remote education and health services. Hence, from a systemic point of view one could argue that rural areas need public networks at par with urban areas, i.e. at 5G levels. However, this mandate depends on the ability to provide complementary inputs for remote education and health services. Till such inputs are made available, the mantra should be good quality 4G for all.

7.4.2. Fixed line infrastructure for 5G in urban and semi-urban areas: A System Requirement

The telecom revolution in India has been powered by wireless connectivity. By the end of January, 2023, wireless subscriptions at 1,143.02 million accounted for 97.63% of total telephone subscriptions, whereas wireline subscriptions at 27.73 million, accounted for only 2.36%. Similarly, wireless broadband subscribers at 806.07 million, accounted for 96.05% of total broadband subscribers. Mobile broadband users alone accounted for 95.91% of subscriptions, while wired broadband subscribers stay at 33.1 million, accounting for only 3.94% (TRAI, 31 January 2023). Wireless connectivity is a large part of not just the access network but also of the backhaul network. For instance, share of microwave in backhaul is estimated to be around 70-80% (Fierce Wireless, 2019).

However, the lack of adequate fiberization will become a big bottleneck for the rollout of 5G as 5G technology uses high frequency spectrum and operates in small cells which need fixed line backhaul connectivity on account of the quantity and speed of data involved. Given the potential of 5G to transform the economy, this amounts to a system requirement of the kind that education was in the early years of the industrial revolution.

The need for the deployment of universal service funds for the purpose of building out fixed line backhaul/fiber to the tower also stems from ‘temporality’, i.e. from the time taken for the buildout that makes it incumbent to start immediately even in advance of the same being part of a consumption norm or a system requirement.

India’s per capita fibre coverage is around 0.09 km, way below its global counterparts (Per capita fibre coverage of China is 0.87 km, while that of the U.S. and Japan is approximately 1.7 km) (Tele.net, 2020). Fiberisation of mobile telecom towers in India is only about 30% unlike the global average of 70–80 percent (Deloitte, 2016). India is behind the global average ranked at 63rd in the Global Connectivity Index (GCI). The National Digital Communications Policy (NDCP) P 2018 has laid emphasis on the “Fibre First Initiative” and aims at achieving 60% tower fibreisation in the country (DoT, 2020). A focused approach to fiberize existing towers and scale-up of fibre connected towers from 35% to 85% in two years would be a preferred as it will yield immediate and quantifiable benefits in 5G and beyond.

7.5. Theoretical Issues: Who to Charge

As of now, telecom operators can be said to inherit the obligation of the government to provide Universal access to communication services, an obligation that flows from the government’s exclusive privilege to provide communication services.
However, currently, this obligation is divided into two parts:

1) A levy that finances the activities involved in the obligation, and
2) the actual buildout of the network which is carried out through a separate process of tendering.

The current structure of Universal Service was formulated in an environment where it could be said that 'the network is the service', in the sense that voice telephony comprised the major service element, and the availability of the network at affordable prices was all that was necessary ensure that the service reached the end users. However, this is not the case today. In a 5G world, a network is only the launching pad on which a thousand services can bloom. Hence, the ecosystem for Universal Service needs to evolve.

The government cannot be said to have an exclusive privilege to provide the plethora of services available today. This implies that the entities in the services layer cannot be said to have a rollout services obligation which then translates into a universal services levy that they are liable to pay for the rollout that is being done by the network providers. Therefore, there is a case that the universal levy should only be charged to the service providers, and the network services providers be absolved of the levy as they are responsible for the physical rollout of the infrastructure.

Thus, a mechanism needs to be created to ensure that the entities riding on the network - communications services providers and significant OTT non-communication service providers, (currently this category would mainly consist of OTT video service providers) - contribute to the build out of the public network. Hence we recommend a Broadband Infrastructure Levy (BIL) on such entities to be charged on the revenues from the use of the public network, net of revenues involving private contracts with network operators.

Given these considerations our design for universal service is described in the following sub section.

**7.6. The Twin Engines of Digital India: Infrastructure supply & Demand**

We propose the USO Fund be renamed as the Broadband Infrastructure Fund (BIF), financed by a Broadband Infrastructure levy on the VNOs, significant OTT communications services providers and significant OTT video service providers, that simultaneously serves two purposes–it finances the build out of the telecom infrastructure, and also ensures those making most use of the network contribute to its development.

Hence, we recommend the following:

1) The Universal Services Levy (USL) as it exists today at 5% of AGR be charged to the network providers to contribute towards USOF;
2) A new Broadband Infrastructure Levy (BIL) of 3% of the AGR to be charged to all VNOs, significant OTT Communications providers, and significant OTT video service providers.
providers on their revenues from their India operations net of the revenue involving specialized contracts they may have entered into with network operators.

The revenue model of the old and new proposals are referred to in the chapter on Licensing.

7.7. Conclusion

The key recommendations for universal service are as follows:

1) Obligation for universal services shall be 4G Plus for all;
2) Recommend upgrade of the fixed line backhaul infrastructure in the country to scale up from 4G to 5G, especially in urban and semi-urban areas of the country using a Broadband Infrastructure Fund;
3) We propose a Broadband Infrastructure Levy to be applied at 3% of India operations to VNOs, significant OTT communication service providers and significant OTT video service providers to contribute to the Broadband Infrastructure Fund. The applicable revenue should be net of revenue earned on the basis of specialized contracts between service providers and the network operator.
4) The Universal Service Levy remains at the government mandated rate of 5% of AGR to be applicable for network providers.

References


Chapter 8. Summary of Recommendations

The technological and business possibilities of a world of 5G technologies and beyond demand a fundamental review of our regulatory paradigms. The report makes a recommendation based on the Indian context, and global best practices. Globally, the regulatory frameworks are still at nascent stages of transformation. India has an opportunity to be a pathbreaker in this area. Hence, we should aim to go beyond our legacy as well as current global best practices to pave the path to the future.

8.1. Technologies

The following technological developments imply that regulation for 5G and beyond must involve a paradigmatic shift from earlier approaches

1) Increased modularization of the various network elements with more software embedded, resulting in unbundling and new stakeholders in the telecom value chain;
2) Network slicing using NFV and SDR as a technology upgradation, leading to provisioning of differentiated services
3) The emergence of CNPNs as the differentiated offering for business and niche use cases.

8.2. Integrated Sphere of Competition

The following business developments imply that regulation for 5G and beyond must involve a paradigmatic shift from earlier approaches

1) The digital sphere as a whole has become an integrated sphere of competition and cooperation between telcos and internet companies.
2) This occasions the development of a new approach – diagonal equity – that envisages similar regulatory treatment of telcos and significant OTTs, hitherto regarded as dissimilar entities on account of the perceived nature of the telco as an essential service, and hence subject to dissimilar regulatory burdens.
3) The details of the application of the approach of diagonal equity in the realm of functional equivalence between OTT communications service providers and standard telco services; net neutrality; interconnection and data portability; universal service; and in the moderation of regulatory levies are highlighted. The implications include search neutrality, interconnection and data portability between OTT communications service providers,

8.3. New Licensing Framework

This section elaborates upon a differentiated licensing regime for the infrastructure and communications services that would reflect the functional separation of infrastructure and services and an integration/convergence of the infrastructure layer. The details are as follows:
1) We create a two layer system of licenses and authorisations for infrastructure and services respectively.

2) In the infrastructure layer, we conceive of an entity - the network provider, that is entitled to bid for spectrum, and that integrates together all the entities in the physical and network layer to provide network bandwidth on wholesale basis to communication service providers. Network Providers shall be mandated to provide equal access on equal commercial terms to communications service providers. They need to fulfill rollout obligations and are charged a license fees and spectrum usage charge (if applicable).

3) In the communication services layer, we distinguish between entities that lease network bandwidth from the network provider, namely the VNOs; and those that are untethered from the underlying network, namely OTT communications providers.

5) Both VNOs and OTT communications providers are divided into significant and non-significant service providers, based on the proportion of traffic carried by them. All VNOs and significant OTT communications providers are charged a broadband infrastructure levy at the rate of 3% of their India revenues from the use of the public internet, net of revenue earned on the basis of specialized contracts between service providers and the network operator.

4) The proceeds of the broadband infrastructure levy are used to fund broadband infrastructure across the country, especially in urban and semi-urban areas.

5) Since OTT broadcast and video services demand large capacity from the underlying broadband, we propose that the broadband infrastructure levy be applicable to them as well.

6) Quality of service requirements shall be applicable to all communication service providers, namely the VNOs, and OTT communications providers.

7) Emergency service requirements will be applied to VNOs.

8) As the heterogeneity of market likely to increase with 5G, we suggest that the granularity of LSAs be increased in line with the UL(VNO) access service license. However spectrum allocation and regulation should continue to be LSA wise.

Table 8-1. Details of Proposed Licensing Framework

<table>
<thead>
<tr>
<th>Type of Licensing</th>
<th>OTT Communications Service Providers</th>
<th>VNOs</th>
<th>Network Provider</th>
<th>Other entities in infra layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interconnection regulation</td>
<td>General Authorization, if significant, else Registration</td>
<td>General Authorization</td>
<td>License required, license fees to recoup administrative costs, spectrum usage charge if applicable</td>
<td>Registration</td>
</tr>
<tr>
<td></td>
<td>Universal interconnection and portability between all</td>
<td>Universal interconnection and portability between all types</td>
<td>Universal interconnection between all types of service providers</td>
<td>No regulation (governed through)</td>
</tr>
</tbody>
</table>
8.4. Spectrum Management

The following points are highlighted in this chapter:

1) While the Enhanced SMRA is being used a standard and well proven auction methodology for allocation radio spectrum, the outcome of the auction is determined by many configuration parameters, especially the reserve prices set at the initial clock round. Regulator shall consider the fixing of the reserve price for different bands in accordance with international prices.

2) The DoT shall provide visibility and roadmap of the amount of spectrum available for commercial mobile services so that the MNOs and others interested in acquiring spectrum can plan accordingly.

3) Flexible approaches to spectrum management including spectrum trading, sharing and leasing shall be implemented for optimal and efficient use of spectrum.

4) Government shall initiate the construction of a geo spatial spectrum database for facilitating dynamic spectrum use options.

5) The carve out of spectrum for CNPNs shall be discussed with stakeholders as these have positive as well as negative consequences. Appropriately it is suggested that spectrum carve outs for CNPNs shall be purpose limited and within a much limited geographical area as is being practiced internationally. The appropriate pricing mechanism shall also be devised.
6) The amount of allocated spectrum in both 2.4 and 5 GHz band for unlicensed use is considerable in India. Any allocation of 6 GHz or 60 GHz band for unlicensed use should be carefully considered so that it does not impact the rollout and growth of licensed mobile services, at the same time nurturing the benefits of unlicensed spectrum for Wi-Fi services. Partial allocation and allocation for indoor use shall be considered.

7) Coexistence of 3GPP unlicensed with Wi-Fi 6E in 6 GHz shall be actively considered as per 3GPP Release 16.

8.5. Net Neutrality to Digital Neutrality

This chapter proposes a new approach—digital neutrality—to replace net neutrality, and bases the recommendation on new technological and business developments in the digital sphere. The following points are highlighted:

1) Transition to a new regulatory approach - Digital neutrality - that recognizes that TISPs as much as CAPs play an important role in creating the next generation of innovations, and that large CAPs as much as TISPs serve as gatekeepers on the internet. Digital neutrality focuses on creating fair competition in all parts of the digital ecosystem including search, e-commerce, and social networks, not merely in the provision of connectivity. Search neutrality is an important part of the new approach.

2) Allocate enough capacity network slices for public network that guarantees 4G-level connectivity.

3) Ensure competitive markets in the provision of network slicing.

4) CDNs should not be made subject to Net Neutrality rules.

5) The space of specialized services should be broadened to include the various possibilities that emerge with 5G technologies.

8.6. Interconnection and Data Portability Regulation

The following points are highlighted in this chapter:

1. The network providers shall facilitate the set up of media gateways of adequate capacity for the interconnection of Internet Telephony services with carrier networks.

2. The significant OTT communication providers shall be mandated to connect with the carrier networks, similar to VNOs.

3. The domestic MTC regime will be reviewed keeping in mind the marginal cost of termination. Bill & Keep should be a commercial decision of similarly sized operators and should not be a regulatory mandate.

4. The international MTC for calls originating in OTT communication apps terminating on PSTN/PLMN in India shall be as per the existing MTC regulations.

5. For the VNOs, the existing regulations on numbering schemes and number portability are applicable.
6. The OTT communication providers shall enable interconnection with other OTT communication apps through open protocols such as XMPP, much the same way internetworking is mandated for carrier networks.

7. The significant OTT communication providers shall be mandated to provide emergency calling service much like the VNOs.

8. The OTT communication providers provide subscriber data portability, similar to number portability as mandated for carrier communication, to enable consumers to port from one OTT communication app to another.

Summary of our recommendations is given in the following Table:

<table>
<thead>
<tr>
<th>License Type</th>
<th>Interconnection</th>
<th>Emergency Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Across PSTN/PLMN</td>
<td>Between Internet Telephony &lt;-&gt; PSTN/PLMN</td>
</tr>
<tr>
<td>VNOs</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>OTT Communication Service Providers</td>
<td>×</td>
<td>√</td>
</tr>
</tbody>
</table>

8.7. Universal Service

The key recommendations for universal service are as follows:

1) Obligation for universal services shall be 4G Plus for all;

2) Recommend upgrade of the fixed line backhaul infrastructure in the country to scale up from 4G to 5G, especially in urban and semi-urban areas of the country using a Broadband Infrastructure Fund;

3) The standard USL of 5% should be charged on the network providers who should be responsible for network rollout;

4) We propose a Broadband Infrastructure Levy to be applied at 3% of India revenues on VNOs, significant OTT communication service providers and significant OTT video service providers on revenues obtained from the public network to contribute to the Broadband Infrastructure Fund.
Appendix-I: Stakeholder Analysis

The following Table provides the summary of the stakeholder interviews that we conducted.

<table>
<thead>
<tr>
<th>Stakeholder Type</th>
<th>Number of Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academia and Research</strong></td>
<td><strong>India: 2; Outside India: 1</strong></td>
</tr>
<tr>
<td><strong>Industry (Mobile Network Operators, Mobile Chip Design firms, Network Equipment Manufacturers, Telecom start-ups, Enterprise service providers)</strong></td>
<td><strong>India: 5; Outside India: 3</strong></td>
</tr>
<tr>
<td><strong>Industry Associations</strong></td>
<td><strong>India: 2; Outside India: 1</strong></td>
</tr>
<tr>
<td><strong>Government Policy/ Regulatory Agency</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>Legal Counsels</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

 Needless to say, the views were not always convergent. We hereby synthesize the views to evolve a comprehensive, long lasting regulatory framework will be our next challenge.

I-1. Telecom and Internet Value Chain

The following perspectives emerged from the interviews: With 4G and 5G, all connectivity services are becoming data services. Thus all connectivity services are moving towards becoming a data connectivity service. The transformed competitive landscape of Digital Services comprises:

1. The new connectivity value chain: software applications gaining prominence at the expense of radio equipment, fixed line connectivity becoming a more essential network element, cloud infrastructure becoming more important, captive non-public networks becoming a significant use case.
2. These developments have brought new entities in the connectivity ecosystem: software vendors, fixed line infrastructure providers, cloud infrastructure providers, industrial enterprises, besides traditional telcos, and radio equipment vendors.
3. Many services previously provided by telcos are being provided by OTTs, example Internet Telephony, Synchronous text Messaging, Real-time video calling, both Peer to Peer and one to many versions. Of course, Toll and Toll Free Services, Emergency Calling Service, roaming services across service providers remains the preserve of telcos.
4. But as OTT services are beginning to substitute telecoms services, and OTTs and other entities are carrying out backward integration into the provision of the network, telcos are also engaging in forward integration into the application layer, and backward integration into the product and device space as they attempt to compete in this changing landscape.
5. The connectivity part of the telecom value chain is shrinking with more value added in other parts such as content. Hence the regulator should look at the entire value chain for regulatory purposes.

6. Networking is the forte of MNOs. However, newer technologies such as cloud platforms, Software Defined Networks -> is where the Big Techs are coming in as competitors to MNOs -> competitive collaboration encouraged by a newer regulatory regime is required for best outcomes/ The MNOs have started working with the tech companies to provide industry-specific niche services.

Hence, we are seeing the emergence of the digital market as an integrated sphere of co-opetition comprising the following entities that are actively engaged in forward, backward, and oblique integration to position themselves in the digital value network:

1. Telcos
   a. Mobile Network Operators (MNOs)
   b. Fixed-line Service Operators (FSOs)
2. Internet Service Providers (ISPs)
   a. Local Cable Operators
   b. Pure play ISPs
3. Software vendors
   a. Operating System vendors
   b. Managed Service Providers
   c. Application developers
4. Over The Top (OTT) firms
   a. OTT Communication providers
   b. OTT Broadcasting providers
5. Equipment vendors
   a. Network Equipment Manufacturers (NEMs)
      i. Carrier equipment vendors
      ii. Enterprise equipment vendors
6. Enterprises
   a. Firms that provide in-house connectivity
7. Cloud service providers

Data connectivity is becoming a commodity and value lies in other parts of the network even though nothing can run without data connectivity. Operators struggling, not seeing viable business with 5G.

I-2. Extant Regulation of the Telecom and Internet Sectors

While the spread of Connectivity up to 4G was led by wireless access and wireless backhaul with licensed spectrum, and a regulator focused on telecommunications, the road ahead requires us to expand along a number of dimensions:

1. development of robust fixed line infrastructure;
2. greater use of unlicensed spectrum;
3. increase appreciation of universal service and spillover effects and reduced focus on short term revenue maximization;
4. greater sharing of infrastructure;
5. appreciation that data connectivity a small and perhaps shrinking part of the digital value network

Thus, we need a bifocal conception of telecom policy with

- clear picture of the transformative developments of the entire digital ecosystem that are underway
- razor sharp focus on a set of issues identified as critical to telecom connectivity

A holistic view is a pre-requisite for appropriate policy and regulatory frameworks for any part of the entire digital ecosystem. There is also a need for a new phase of institution building as this new landscape requires an integrated institutional framework with different elements deeply interconnected and aligned.

At the same time, institutional structures for policy and regulation for ‘verticals’ like telecom service, infrastructure etc. are appropriately defined, are critical.

The following points emerged from the discussion with stakeholders:

1-2.1. Scope and Extent of Regulation

1. Don’t limit the study to 5G, but 5G and beyond as the regulations should stand the test of time for the proposed 6G in 2030 as well as future generations.
2. The mindset of the Government should be not to view the telecom industry as a source of revenue; but analyze the spill-over effects; the Finance ministry needs to look at this actively.
3. The objective of telecom regulation should be clearly defined -> universal access, consumer interest, increased competition? It should not be maximizing revenue.
4. Regulation and policy have been agnostic about technology evolution. Telecom sector regulation was always about scarce natural resources being put in to place. Regulation and the draft Telecom bill ignore all aspects of innovation.
5. License conditions for telecom are quite stringent -> call monitoring, providing information to the State for national security, -> are very stringent compared to any other regulated industries.
6. Separate infra and services and formulate regulations and rights across these broad two layers may be an option to deal with this issue.
7. Integration of regulation of the tech sector and telecom sector are evolving. They were treated separately until OTT consultation paper was initiated by TRAI.
8. Breakup of services and associated regulation across the OSI model -> physical to network layer -> telecom infra providers; OTT -> app layer. A different view is to look the value chain across 3-tiers: (i) infrastructure layer: active and passive; (ii) bearer or logical layer; and (iii) applications and content layer. Define policy objectives for each; identify stakeholders across the layers; apply regulatory principles as appropriate across the different layers.
9. Light touch regulation is very aspirational; the Indian telecom regulators use overreaching regulations instead of light touch; example -> data localization rules.
10. If there are overlapping regulations, the one that has come up early will override any others in general common law principles.
11. We need to also augment capacity and autonomy of the sector regulator.
12. 5G revolution requires fibre to the building, to the classroom. Urban involves ROW problems, but for rural even ROW problem not there. This will solve the backhaul problem. Further, fixed wireless may be solution; however, it is difficult to get fibre to home. So fibre to lamppost, shall be an option. The utility company should lay fibre as they have the RoW. Deployment of fixed landline networks is still challenging due to RoW and in-building solutions. Sharing of infrastructure necessary to tap 5G potential. Though we have allowed sharing of both passive and active infrastructures since 2016, the uptake of sharing is still poor.
13. Backbone is the key for good broadband connectivity. India lags behind in backbone without which the 4G/5G access networks are not of much use. Need fillip to building high capacity and robust backbone.
14. There should be interoperability of VOIP services as well. Hence the interconnection regulation as applied to MNOs shall be applicable for OTTs as well.
15. We are not even fully utilizing the efficiency of 4G technologies as the speed experienced is not even ⅓ rd of what is witnessed elsewhere.

I-2-2. Regulatory Institutions

1. Need for an independent cadre, financial and autonomous regulator in TRAI; cadre should invite experts from the industry, academia at market price as consultants (TVR).
2. UK is coming up with horizontal unit called Digital Economy Unit to deal witty regulator issues across the digital value chain.
3. Extra territorial jurisdictional regulations are not refined to addressed to OTT firms and services; for example, the Internet Telephony restrictions as imposed under Unified License did not work well.

I-2-3. Data Protection and Privacy

There has been global regulatory momentum after the Cambridge Analytica scandal to tighten the data protection and privacy regulations around the world. With the enactment of European Union General Data Protection Regulation (EU GDPR), there severe sanctions and penalties for violating privacy of natural persons as defined in the regulation. The effect of tightened data protection regulation is often found in the applications offered by the OTTs. Following are some of the stakeholder responses received regarding data protection regulation as applicable to the OTTs:

1. OTT firms are subject to the following regulation:
   b. Data Protection Regulation related to privacy and data protection regulation
   c. Tax regulations as per Digital Tax regulations; good progress has been made on addressing tax evasions by the OTT and other multinational Internet firms.
2. OTT firms shall be required by regulation to keep consumer data within the country. It is possible to enforce. However, the knowledge activities such as profiling the
customers cannot be restricted by jurisdictional regulations. If the firm is registered in India, it may be possible to exercise regulatory control becomes that much easier.

I-3. Antitrust and Competition

Both policy formulation and competition regulation need to be based on clear perspectives with regard to the relevant market of the entities they aim to make policy for or regulate. These perspectives would have overlaps but need not be identical since a policy maker has broader goals than the regulation of market power. These include universal access, technological dynamism, national security, and so on. A key question for a policy maker formulating policy for 5G relates to the appropriate boundaries for their policies. Since the rise of the mobile internet, telecom policy has always been part of a larger space of policy making related to the digital sphere as a whole. However, in today's world, is it possible to make optimal telecom policy without first gaining an understanding of the transformational changes underway in the digital sphere?

I-3.1. Substitutable or Complementary Services

When we take a holistic view, we must ask: in what relation do telecom services and internet services - specifically Internet based Over the Top (OTT) communication services stand with respect to each other? Are they complementary as they are generally considered to be or are there new elements of competition in their relationship? And if they are elements of competition, what is the appropriate policy response?

The following table summarizes views from stakeholders on arguments in favour of complementarity of telecom services with OTT communication services versus arguments in favour of substitutability of such services.

<table>
<thead>
<tr>
<th>Arguments in Favour of Complementarity</th>
<th>Arguments in Favour of Substitutability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since the Over The Top (OTT) services cannot be provided without the underlying connectivity and the connectivity provided by the Mobile Network Operators (MNOs) is of no use without content and applications, they can be viewed as complementary services and not as substitute services</td>
<td>The digital sector needs to be as a whole, not as divided into connectivity providers and OTTs</td>
</tr>
<tr>
<td>Since the OTT and Content and Application Providers (CAPs) are regulated in other forms such as content regulation, privacy regulation, and so on, imposing the same regulations as applicable to</td>
<td>The regulations and laws should be not different for different types of companies, but they should be per services provided and business they do.</td>
</tr>
</tbody>
</table>

Table I-2. Telecom versus OTT Communication Services
| MNOs, such as contributing to USO levy is not applicable. | For OTT regulation, the European stand is that only if there is danger that a company internally subsidizes one business sector with the income of another so that it faults the competition in the subsidized business, such large companies are required to separate those business sectors into different legal entities. This has happened for example in ADSL where the ownership of access lines (telephone pair cables) and provision of broadband services to consumers has been separated and unbundled. The telecom sector is extremely tightly regulated and hence there are antitrust regulations for protection if a large company provides both content and access services as they are licensed and regulated separately already now. In Finland for example, we have not seen OTT companies to be interested in access services but the MNOs have become e.g. content providers of pay-TV and cable TV |
| Social media giants like Facebook/Meta will never enter into the market of telecom infrastructure provision and displace incumbents as they don’t want to be seen as ‘infrastructure companies’; what they may do if there is scope for value addition, is help connect the infrastructure network of one company with another | There are evolving platforms such as Infrastructure as a Service, provided by passive infrastructure providers such as telecom tower companies, utility firms that have passive or active infrastructure (e.g. fibre bandwidth), MNOs, cloud service providers (e.g. Amazon or Microsoft), Network Equipment Manufacturers (e.g. Nokia, Cisco), and Neutral Hosts. These are in turn used by enterprises, Mobile Virtual Network Operators (MVNOs) and OTTs for providing 5G private or public services. These platforms can be championed by MNOs, Neutral Hosts, CAPs, cloud service providers or even enterprises that have CNPNs. |
| One possible licensing methodology is to separate connectivity infrastructure from services offered by issuing two types of licenses: (i) Infrastructure License and (ii) Service License | Need facility based competition, with liberalization of telecom licenses to include global internet companies. Distinguish between facility-based vs. service based licensing. Licensing of OTTs need not imply an onerous process, provided it is open, and transparent. It can be light touch with “registration” instead of heavy handed licensing conditions as OTT is not facility based. |
| MNOs have exclusive rights to spectrum, | Digital rights are driving competition, telecom is
numbering scheme, and RoW. On the other hand, OTTs do not have; for example, they cannot participate in auctions to obtain unlicensed spectrum. OTTs cannot do most of what MNOs can do. They have only data for their monetization. This option was available for MNOs as well. Hence there is no level playing field

| part of a larger internet value chain consisting of- | content, online services, enabling technologies, connectivity. |

I-3.1.1. Other Issues

1. We will see evolution of the ecosystem with NEMs, MNOs, cloud providers, and enterprises appropriating value at each node of the value network.
2. There are three scenarios in the telecom value network - a) Status quo with current equipment vendors and MNOs. b) Decentralized with greater variety and number of entities. c) Centralized with new entities like OTTs or cloud service providers gaining dominance.
3. The sector today is very different from what the sector was when TRAI Act was formulated. What is being regulated needs to be determined. Is the TRAI Act a bottleneck?
4. Aim of the regulator is to control two objectives - maximize benefits and minimize harms to Indian consumers. India needs native platforms.
5. We need a telecom sector regulator to regulate connectivity infrastructure.
6. One way is to look at the 3 platforms - identity, payment, and connectivity and provide regulatory guidelines for each.
7. Creation of a level playing field is in the policy domain, not antitrust. In Antitrust, the lens used is whether there is market dominance abuse and erecting barriers for competition in the “relevant markets”; the relevant markets can be case dependent and can be narrower compared to economic markets.
8. Should the issue of cash burning be discussed at a policy and antitrust level? Is there a threshold at which VC capital leads to predatory pricing- at which point of time antitrust regulation comes into being?
9. Antitrust in horizontal M&A has defined thresholds; on the other hand, for vertical M&A, the lens for the regulator is to account for the economies of scope of the services that are beneficial to the consumers; however only when the vertical M&A related to creation of entry barriers for competition, and discourages competition, the case does not arise any antitrust concerns.

I-3.2. Net Neutrality Debate

1. Net neutrality is one of the buzzwords of the past 20 years. Rather than sticking to a buzzword it is more important to understand what the restrictions called net neutrality try to protect. Saying that everything has to be according to net neutrality is like saying that all software has to be open source, all publications must be open publications or
all media distributions have to be available for everyone. The government has to ensure that vital services are available for all citizens but it does not mean that all commercial services are available for all (SY).

2. Content distribution networks privilege certain CAPs, hence violate net neutrality. But since focus is on telco actions this goes unnoticed.

3. Net Neutrality shall be equally applicable for both telecom and content providers.

4. In 5G, technologies such as network slicing may lead to prioritization of data across customers, both business and retail. If it affects retail customers, it may be in violation of Net Neutrality rules.

I-3-3. Re-sizing the LSAs to improve competition

1. Re-sizing at granular levels to suit enterprise CNPNs may not be viable and optimal. However, reducing the current size of LSAs to smaller ones can increase competition levels.

2. Along with the larger LSA based licensing, we need to evolve a light touch flexible licensing model for smaller areas including city and taluk levels to address specific communication needs of these local communities. This should not have huge reserve prices and hence provide an alternative to MNO connectivity. Local players such as Local Cable Operators could get spectrum and run 4G/5G networks at much reduced and affordable prices.

I-4. Spectrum Management and Regulation

A key function of telecom policy is the create an environment for the rapid, efficient, and equitable use of spectrum, an invaluable natural resource. The following sections summarize important perspectives in the minds of stakeholders.

I-4-1. Spectrum Allocation

1. Spectrum management assumes importance in countries where Mobile First is the norm and where the landline broadband is inadequate.

2. Spectrum should not be high priced; should not leave spectrum unsold due to higher prices.

3. Though 700 MHz is picked up by one operator, the high prices for not selling 600 and 700 MHz is wasteful of the scarce spectrum.

4. Combine lower reserve prices with better coverage obligation, especially for low band spectrum, especially for coverage in rural and remote areas.

5. The uncertainty in the 600 MHz band plan (APT band plan) seems to be a bottleneck for purchase as the ecosystem is not yet ready for this band plan.

6. Railways trying to get 700 MHz band; we have seen public utilities acquiring spectrum in other countries; should the spectrum be set aside? GSMA -> more spectrum for public use. Artificial carve-out reduces the amount of spectrum available for public use.

7. The E and V bands are extremely useful for 5G as well as backhaul. Regulators have not really thought about these bands yet. As long as there is no scarcity in these bands, and mostly not being used for access services, it may be conservatively priced. Simple
light licensing framework based on registrations using geo-location spectrum database tends to be increasingly used for this high-band spectrum allocation. Interference concerns are not tricky due to high frequencies.

8. For efficient allocation and use of spectrum across defense, broadcasting, mobile and so on, omnibus agency is required. This can be hosted in a neutral government organization such as NITI Aayog. Possible to relocate WPC experts in to NA for the same. In the existing institutional arrangement, the ministries looked with askance at whether WPC - the spectrum management agency now will favour mobile services.

I-4-2. Captive Non-Public Networks (CNPNs)

One of the recurrent themes in 5G is the deployment of Captive Non-Public Networks (CNPNs) that are customized to the needs of businesses, and enterprises. It is envisioned that 5G networks can provide the required bandwidth, ultra-reliability and low latency specifically suited to the stringent requirements of enterprises. Though MNOs are better suited to provide CNPNs through their enterprise offerings in licensed spectrum, CNPNs constructed by non MNOs such as NEMs, enterprise equipment vendors, cloud service providers, or managed system providers are becoming a norm. While enterprises do have the choice of building Wi-Fi on campus networks operating in unlicensed spectrum bands, there are a number of use cases where the on premise networks can also be deployed as 3GPP networks using licensed spectrum. There have been arguments on whether spectrum carve outs for CNPNs is desirable, following table summarizes views from different stakeholders in favour and against spectrum carve outs.

**Table I-3. Spectrum Carve-outs or not for CNPNs**

<table>
<thead>
<tr>
<th>Arguments in Favour of Spectrum Carve-out for CNPNs</th>
<th>Arguments against Spectrum Carve-out for CNPNs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulations will have to realize the dichotomy between public networks and private networks. The rules have to be carved for these two different types of networks accordingly.</td>
<td>Regulations for local non-public networks are often not stringent compared to the highly regulated public network provisioning by MNOs.</td>
</tr>
<tr>
<td>Spectrum should be put to use efficiently for the benefit of the residents at large, irrespective of their location, income, etc. If that involves allocation for private use, then it should be done.</td>
<td>The carve out for non-public networks reduces spectrum available for public networks. Setting aside valuable spectrum close to 100 MHz - take up is not successful in many cases such as in Germany. Spectrum in these set asides are not optimally used. GSMA cautions against this set</td>
</tr>
<tr>
<td><strong>As long as they do not interfere with the working of the PLMN, it should be OK to reserve and allocate spectrum for private use. Since it is for a limited purpose, the regulatory conditions applicable for private networks shall not be the same as for public networks.</strong></td>
<td><strong>MNOs are well positioned to serve CNPNs. In many EU countries, leasing of the MNOs to enterprise services is allowed. The CBRS system is complex and has not seen large uptake for General Authorization. MNOs have preferred their networks in the licensed band of 3.7-3.9 GHz.</strong></td>
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<tr>
<td><strong>In some countries, the MNOs are not allowed to obtain spectrum for provisioning CNPNs. This is due to avoid dual allocation of spectrum in the same area in which MNOs have licensed spectrum allocated to them for Public Land Mobile Network services.</strong></td>
<td><strong>Spectrum for CNPNs are often much less compared to that available for macro coverage by MNOs so that the local network operators do not compete and outperform MNO.</strong></td>
</tr>
<tr>
<td><strong>If the spectrum available to the MNOs is not large enough, then CNPNs outperform</strong></td>
<td><strong>Network slicing can be very effective if the spectrum available to the MNO is large enough to do the slicing and offer differentiated Quality of Experience to the users. Hence this can effectively compete with QoE offered by the CNPN operators.</strong></td>
</tr>
<tr>
<td><strong>In areas where the MNO connectivity is poor (i.e. remote areas), private networks can be deployed by Neutral Hosts and shared with MNOs</strong></td>
<td><strong>In dense urban areas, for indoor coverage local public networks can be deployed by NH with sharing arrangements with MNOs. In areas where MNOs are already present (e.g. airports) where outdoor connectivity is a requirement, MNOs provide local private networks preferably through Network Slicing.</strong></td>
</tr>
<tr>
<td><strong>CNPNs should be encouraged as the enterprise or the premise owner knows the quality of service requirements much better than MNOs. There are at present about 794 private networks in operation worldwide. The private 4G networks existed in Seaports, Airports, and industries for quite long. Hence it should be encouraged. Further, since it is for private captive use, the same licensing conditions as applicable for MNOs should not hold good for CNPNs.</strong></td>
<td><strong>In some countries such as the UK, sharing of spectrum between MNOs and private enterprises for constructing CNPNs is allowed; however, in most countries it is not allowed.</strong></td>
</tr>
<tr>
<td><strong>If the private networks are run professionally on a large scale, then buying capacity from those networks might be interesting especially for MVNOs but not likely to MNOs. There are</strong></td>
<td></td>
</tr>
</tbody>
</table>
initiatives to encourage neutral host type of arrangement for ideological reasons, e.g. https://worldmobile.io.

<table>
<thead>
<tr>
<th>Indian CNPN licensing framework (administrative licensing) is well in line with the recent private IMT spectrum assignments in several industrial nations including US, Chile, UK, France, Germany, Netherlands, Sweden, Finland, Slovenia, South Korea, Japan, Malaysia and Australia.</th>
<th>Spectrum for CNPNs are normally administratively allocated in most countries and such fees cover only the regulatory administration costs; it is around $1500 in most EU countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is still easier and flexible for CNPNs to be constructed as Wi-Fi networks (with Wi-Fi 6 available) compared to constructing an IMT 3GPP CNPNs.</td>
<td>Carve outs are risky in main 3GPP bands such as 3.5 GHz. Japan has set aside 4.5 GHz (not the main 3GPP band) which is less risky.</td>
</tr>
<tr>
<td>There are strong use cases for constructing 3GPP local networks using 3.3-3/6 GHz band; there are serious limitations of using the 26 and 42 GHz for local networks due to propagation limitations. Hence the regulators should definitely look at suitably allocating the 3.3-3.5 GHz band for MNOs and CNPNs.</td>
<td>Artificial barriers not to include MNOs in the CNPNs as in Germany should be avoided. The enterprise users should not be subsidized by the higher auctioned spectrum prices of the MNOs.</td>
</tr>
<tr>
<td>Initially, though MNOs will possibly extend enterprise services for CNPNs, other competitors such as building owners, and enterprises will start providing CNPN in the near future.</td>
<td>Neutral hosts have been discussed as a potential business model at least for a decade but very little has happened. Neutral host business cases might exist but they are probably very specific, e.g. train lines or large stadiums and the model could be difficult to apply more generally.</td>
</tr>
<tr>
<td>Neutral hosts have been very successful in tower sharing (passive infra sharing). But the quantum of investment in indoor infrastructure has been low, say 5%. But indoor networks will take a much higher share with 5G (20-30%). As that happens, the neutral host journey will migrate from optic fibre to towers to indoor infra.</td>
<td>Neutral hosts will be mostly the building or site owners who build the 5G network for their main tenants -&gt; enterprises. Examples include SEZs, Software Parks. The anchor tenant wants reliability and good connectivity and hence requires a robust private network; even superior to the Wi-Fi indoor networks. The Neutral Host provides these services to the anchor tenant and possibly lease part of their infra (e.g. network slice, indoor access to antennas) to MNOs. MNOs extend their public network services inside the CNPN area.</td>
</tr>
<tr>
<td>Wi-Fi is not guaranteed to provide the required QoS for enterprises. Hence 3GPP networks with infrastructure provided by the enterprise NEMs and</td>
<td>Configuring a mobile IMT network is very complicated compared to Wi-Fi. Spectrum carve-out for CNPN requires a neutral host who is not an expert in building an IMT network to obtain services from a third party to construct such a network. MNOs probably do not want to use such networks which are not resilient and robust. So there is very little demand and supply for neutral host arrangements between private IMT network owners and MNOs.</td>
</tr>
</tbody>
</table>

Neutral hosts will be mostly the building or site owners who build the 5G network for their main tenants -> enterprises. Examples include SEZs, Software Parks. The anchor tenant wants reliability and good connectivity and hence requires a robust private network; even superior to the Wi-Fi indoor networks. The Neutral Host provides these services to the anchor tenant and possibly lease part of their infra (e.g. network slice, indoor access to antennas) to MNOs. MNOs extend their public network services inside the CNPN area.
I-4-2-1. Other Issues

Apart from the above, the stakeholders also commented on the general model of CNPNs and the associated regulatory issues:

1. Here are the following possible business models and ecosystem for local networks. These results in increased competition to the typical oligopoly industry structure of the MNOs.
   a. Vertical in which the MNO provides infra and services for local captive use;
   b. Horizontal in which neutral hosts who construct and provide local network services also share the infra with MNOs for MNO customers;
   c. Oblique: MNO collaborates with neutral host.

2. If municipalities are to become neutral hosts, fibre has to reach lamp posts. France has incentivized municipalities well.

3. Active sharing of infra, though recommended by TRAI is not yet taking place. Sharing of the non-competing elements should take place for improving efficient use of scarce resources.

4. MVNO licenses should be revised; now one MVNO cannot home in to more than one MNO; this will not induce MVNOs. This needs a re-visit in the context of CNPNs.

5. In most countries spectrum for CNPNs is administratively assigned; the main reason being the demand for this is difficult to estimate.

6. The Citizens Broadband Radio Service (CBRS) framework is mainly targeted at innovation and experimental in nature; not from the main roll out of PLMNs. Objectives of CBRS are quite different compared to PLMS uptake.

I-4-3. Coexistence of Licensed and Unlicensed Networks

There is also the debate as to whether the unlicensed spectrum and licensed spectrum are complementary or substitutable. While the Internet firms have been arguing for more release of spectrum in the unlicensed bands, specifically in the 6 GHz and 60 GHz band, the MNOs have been arguing that more value is generated when these are licensed. The following Table provides the contrarian views on the licensed versus unlicensed spectrum issues:
<table>
<thead>
<tr>
<th>Arguments in Favour of Unlicensed Spectrum</th>
<th>Arguments against Unlicensed Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worldwide the unlicensed spectrum is about 12 MHz while in India it is just about 650 MHz Woefully inadequate. Balanced regulation of licensed, unlicensed and shared spectrum is needed. We have lopsided regulatory attention to license spectrum. The recommendations made by TRAI on unlicensed spectrum are stopped at DoT. We need to have this passed against the intense lobbying by the MNOs. More of Wi-Fi, and more of fibre to utilize the 5G and beyond technologies.</td>
<td>Robust and reliable backhaul is required for Wi-Fi connectivity; hence a balanced approach to mix and match Wi-Fi and 3GPP networks is warranted.</td>
</tr>
<tr>
<td>There will be increased coexistence of 3GPP and Wi-Fi integrate networks in the CNPN space. While 3GPP provides guaranteed QoE, Wi-Fi reduces cost and provide increased capacity for local networks</td>
<td>LTE Unlicensed is not successful.</td>
</tr>
<tr>
<td>Both unlicensed and licensed spectrum are complementary; especially in FW cases, a balanced approach is required. Majority of resistance for PM WANI is coming from MNOs.</td>
<td>All FWA operators outside the USA would prefer dedicated licensed spectrum over unlicensed spectrum. So there is very limited demand and supply for FWA unlicensed outside the USA. Both unlicensed and licensed spectrum are complementary; especially in FW cases, a balanced approach is required.</td>
</tr>
<tr>
<td>Worldwide the unlicensed spectrum is about 12 MHz while in India it is just about 650 MHz Woefully inadequate.</td>
<td>If 5G fixed access provided by MNOs also counts as Fixed Wireless Access(FWA), then many European countries are experiencing an increase in FWA. From a European perspective, it is difficult to see any impact with Wi-Fi 6 in FWA. In Europe, so-called standard power, which is required for 6 GHz outdoors FWA, is selected as a study item in CEPT, but it will take a very long time before it even gets the written report out.</td>
</tr>
<tr>
<td>Unlicensed spectrum allocation in India in the 2.4 and 5 GHz bands are quite abysmal compared to the international average. We should unlicensed</td>
<td>Backhauls are even more important than Fixed Wireless Access. It is difficult to imagine anyone seriously providing backhaul services without protected licenses or with unlicensed spectrum</td>
</tr>
<tr>
<td>The US used light licensing over small license areas. We could do the same.</td>
<td></td>
</tr>
<tr>
<td>more spectrum for the unlicensed as this will bring innovation in connectivity.</td>
<td>The 6GHz band -&gt; for providing good connectivity with large contiguous bandwidth for limited area networks -&gt; 3GPP priority. Mid band spectrum requirement is about 2GHz as per GSMA. The 6 GHz for 3GPP networking is very important.</td>
</tr>
<tr>
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</tr>
<tr>
<td>For small cells, Wifi6 is a substitute for 5G licensed spectrum bands at very low cost. Existing infrastructure can be reused. It provides comparable quality. It is integrated with 5G core (has been since 4G). A successful test done in UP manufacturing unit with IOT.</td>
<td>Coexistence could mean that 5G Unlicensed is used in the Wi-Fi6 band. A few countries like the US and Canada have allocated 5925-7125 MHz to unlicensed Wi-Fi. Use of 6425 - 7125 in other regions will be discussed in World Radio Conference 2023.</td>
</tr>
<tr>
<td>Coexistence could mean that 5G Unlicensed is used in the Wi-Fi6 band. A few countries like the US and Canada have allocated 5925-7125 MHz to unlicensed Wi-Fi. Use of 6425 - 7125 in other regions will be discussed in World Radio Conference 2023.</td>
<td>Co-existence of Wi-Fi and 5G 3GPP networks are definitely possible. Since QoS requirement of private networks can be stringent, firms that deploy private network might prefer 3GPP network over Wi-Fi.</td>
</tr>
<tr>
<td>World over 60 GHz is being unlicensed; in India we are thinking about auctioning. This spectrum though could be useful in only select use cases, can provide indoor coverage. Hence frequencies in this band should be unlicensed.</td>
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</tr>
<tr>
<td>Public Wi-Fi penetration across the country needs to be improved for equal, affordable and ubiquitous access across regions of the country. PM WANI is likely to take us there.</td>
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</tr>
<tr>
<td>WiFi6 will trigger OEM ecosystem and Make in India initiative.</td>
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</tr>
<tr>
<td>Wi-Fi could be used in CNPN, if entities like Cisco act as anchor.</td>
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</tr>
<tr>
<td>Wifi has power limitation, interference, requirement to back off, so not reliable.</td>
<td>Wifi has power limitation, interference, requirement to back off, so not reliable.</td>
</tr>
</tbody>
</table>

**I-4-4. Global Spectrum Management**

Globally, spectrum management and allocation is extremely well organized on paper and in practice. On a global level it is ITU-R, ITU-R WRC, then there might be regional bodies like CEPT and European Commission in Europe, and then national spectrum management responsibilities between e.g. military and civil spectrum management are set in national legislation. The legislation sets the frame that the National Regulatory Authority has to follow. Within the rights and responsibilities of the NRA, it may use commercial tools and services to accomplish the spectrum management tasks. However, there are various views on the coexistence of spectrum bands for various services, specifically as related to satellite networks and PLMNs as given below:

1. Satellite spectrum and 3GPP co-existence has been formulated and is used by OFCOM in the UK. The Satellite has very less subscriber base because of huge CPE
cost; hence should not be allocated exclusive spectrum; but on a shared basis administratively assigned.

2. Coordination of administratively allocated satellite spectrum and 3GPP spectrum can be done by mutual agreements between the service providers as one for 28 GHz by OFCOM.

3. LEO (NGSO) satellite backhaul can augment terrestrial networks in rural and remote areas.

4. Coexistence of LEO and Terrestrial mobile spectrum: In 3.5 GHz, India has done well with the release of about 300 MHz for continuous band plan. In Ka band (28 GHz) -> coexistence problem exists; eco system for mm wave band is well developed in the 26-28 GHz; hence much attention worldwide this band for 5G services. Might be an opportunity to use differentiated priorities for land mobile and satellite networks. Example -> Australia has done well on this.

I-5. Interconnection and Interoperability

One of the important aspects in the evolution of network equipment is the incorporation of modularization and software in to the mobile networks, extending all the way from the Radio Access Network (RAN) to backhaul. The paradigm shifts in the development if Virtual RAN, Cloud RAN and Software Defined Networks (SDN) has led to the following:

a) More software components replacing the hardware components;
b) Inclusion of cloud based architecture where the network intelligence is migrated from the access nodes to the cloud;
c) Development of open modular standards such as Open RAN (O-RAN) as an alternative to proprietary monolithic architecture by the NEMs.

In this section we posed questions on the above developments and following are the responses from the stakeholders:

1. Open Radio Access Network (O-RAN) provides modularized radio access components for any NEM including start-ups, cloud providers, enterprises to possibly construct 5G networks on their own.

2. However, O-RAN architecture is still evolving and not as matured as the 3GPP standard network elements provided by large OEMs (e.g. Nokia, Ericsson and Huawei). Hence at this stage of evolution, O-RANs are suitable for building small CNPNs and not really for large country wide PLMNs.

3. Decoupling of radio vendors from centralized and distributed unit vendors will be the biggest contribution of O-RAN; That is decoupling RAN from the DU/CU core is a major contribution of O-RAN as this provides an interoperable framework for multiple vendors to come in (even start-ups) in the telecom equipment ecosystems.

I-6. Universal Service

There has been a long time debate on whether the Universal Service Obligation (USO) Fund is any more required as we reach saturation in mobile network connectivity. The hugely
debated issue is the unspent USO fund and whether there is a need to continue the Universal Services Levy (USL) on the licensed MNOs. There is also contention as to whether the USL and the associated disbursement of USFO shall be extended to the OTTs as well when we embark on 5G and beyond networks.

1. The MNOs who contribute to the Universal Service Obligation Fund (USOF) shall have a say on how it is to be distributed.
2. BharathNet which has been funded by the USOF has last mile connectivity problems still and the model for rolling out services over Bharath Net has not yet happened successfully.
3. Digital infrastructure (as defined in ITU) including mobile, landline, satellite (less than 10% on International average), public Wi-Fi (less than 1% of the International average), data centres and fiber roll-out need to be improvised from our pathetic state in all the other areas, except for mobile. India is over-dependent on mobile. Hence a balanced infrastructure development across all areas is needed.
4. Need to take rural fibre down to enterprises - schools, hospitals. Rest should get a 4G signal. 4G network should be shared to provide universal coverage.
5. Need to have a mechanism of providing a last mile access network using shared passive as well as active network infrastructure is needed for the rural areas.

I-7. Concluding Remarks

In this report, we have captured the viewpoints of most of the stakeholders of the telecom/digital value chain using a semi-structured interview. The responses though are polarized have given valuable inputs regarding how the regulations need to evolve in tune with the technical and market developments in the era of 5G and beyond. The comments and opinions along with existing research, both by academia and industry bodies will be used to provide policy and regulatory prescriptions.
Appendix-II: International Best Practices

The following international best practices have been quoted at various points in the report:

1) Diagonal equity: While the term ‘Diagonal equity’ has been coined by us, many of the conclusions flowing from this approach are being adopted in various countries. These include

   a. The Directive (EU 2018) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast). Text with EEA relevance recognizes the functional equivalence of OTT communication services and standard telecom services despite their differing operational models. In US, the FCC classified text messaging as ‘information services’ under the Communications Act to preserve regulatory parity between text messaging and internet-based messaging services such as WhatsApp and iMessage, which are lightly-regulated information services under the Act.  

   b. Upholding the principle of search neutrality as an essential feature of anti-trust regulation. In 2017, the European Commission fined Google €2.42 billion for breaching EU antitrust rules by giving an illegal advantage to another Google product, its comparison-shopping service, and thereby abusing its market dominance as a search engine. In US, the Restoring Internet Freedom Order, 2017, undid the 2015 Open Internet Order’s ban on “paid prioritization” arrangements (i.e., those favoring certain traffic in exchange for compensation or some other benefit).  

   c. On interconnection, EU 2018 states ‘A national regulatory authority may, in accordance with Article 68, impose obligations of non-discrimination, in relation to interconnection or access.’ It further states ‘A national regulatory authority may, in accordance with Article 68, impose obligations for accounting separation in relation to specified activities related to interconnection or access.’

2) Functional Separation of Infrastructure and Services: EU 2018, article 70 states that ‘Obligations of non-discrimination shall ensure, in particular, that the undertaking applies equivalent conditions in equivalent circumstances to other providers of equivalent services, and provides services and information to others under the same conditions and of the same quality as it provides for its own services, or those of its subsidiaries or partners.’ This provision could be used to ensure vertically integrated entities do not privilege their own service offerings. In the US, the FCC had experimented with functional separation with AT&T but had reversed course after concluding the efficiency costs of such separation outweighed any possible benefits. Instead, the United States has since pursued a "behavioral" approach, imposing and enforcing a "carrot and stick" system of incentives to encourage incumbents to offer wholesale services on a nondiscriminatory basis.

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18 https://www.repository.law.indiana.edu/cgi/viewcontent.cgi?article=1563&context=fclj (page 531)
3) Levy on OTT video services: A carriage fees is under active consideration in the EU. The possibility that this fee may entail a contribution to a broadband fund instead of a direct payment is also under consideration. In the US, telecom service providers are obligated to pay a percentage of their interstate and international end-user revenues to the Universal Service Fund. In recent times, FCC has also considered proposals to impose the levy on OTT video services, in discussions on the future of Universal Service Fund.19,20

4) Best Practices in spectrum management: The following changes in line with our recommendations are being undertaken: Reconsideration of fixing the reserve price based on international benchmark prices (Sridhar & Prasad, 2021); many countries have allocated carve-out spectrum for CNPNs to non-license holders; 6 GHz spectrum is being de-licensed in many countries to improve Wi-Fi penetration. Digital neutrality: The concept of digital neutrality is inherent in the growing use of the non-discrimination principle in EU to prevent powerful OTT intermediaries from favoring allied services or products. In recent years, in US, there has been bipartisan support on a slew of anti-trust legislations such as the Ending Platform Monopolies Act, The Platform Competition and Opportunity Act, etc. which aims to reduce abilities and incentives of dominant online platforms to use its control over multiple business lines to preference itself over competitors.21

21 https://www.vox.com/recode/22529779/antitrust-bills-house-big-tech
## Appendix-III: Deployment of CNPNs: International Practices

<table>
<thead>
<tr>
<th>Country</th>
<th>Non-MNO</th>
<th>MNOs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>• In 2020, Finland issued its first private cellular licence for industrial LTE and 5G at 2.3 GHz. It was granted to State-owned energy company Fortum Power and Heat for its power plant in Loviisa. • Steveco shipping terminals in Kotka • KymiRing motor • Konecranes</td>
<td>• Elisa operates UROS and Qualcomm’s private 5G network at an IoT innovation centre in Finland.</td>
</tr>
<tr>
<td>Germany</td>
<td>• Bosch is operating its own 5G private network at its lead plant in Stuttgart-Feuerbach. • Frankfurt based airport operator Fraport has a licence from German regulator BNetzA to run its own 5G network in the airport vicinity in the 3.7-3.8 GHz band. • EDF • Volkswagen • Rohde &amp; Schwarz</td>
<td>Deutsche Telekom, Vodafone and Telefonica are operating most of the private 5G networks in Germany.</td>
</tr>
<tr>
<td>France</td>
<td>• The airport operator, ADP Group and its subsidiary Hub One, have been granted a 10-year 4G and 5G license by ARCEP in February 2020 to be used in Paris’ airports. • The major French electricity company EDF has also been awarded a 10-year license in the 2.6 GHz</td>
<td>Orange is operating most of the private 5G networks</td>
</tr>
</tbody>
</table>

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22 https://www.rcrwireless.com/20200707/5g/finland-issues-first-private-lte-5g-licence-urges-industry-to-pile-in
24 https://www.rcrwireless.com/20220720/5g/frankfurt-airport-appoints-ntt-to-deliver-europes-largest-private-5g-network#:~:text=Fraport%20has%20licences%20for%205G%20network%20in%20the%203.7%2D3.8%20GHz%20band.
25 https://5gobservatory.eu/5g-private-networks/
26 https://5gobservatory.eu/5g-private-licences-spectrum-in-europe/
<table>
<thead>
<tr>
<th></th>
<th>TDD band (20 MHz) on the Blayais nuclear power plant located on the banks of the Gironde estuary near Blaye.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• The mobility company TransDev has also been allowed to use the 2575-2595 MHz spectrum in Rouen, North West of France from 12 March 2020 to 11 March 2024.</td>
</tr>
<tr>
<td>Hungary</td>
<td>5G private networks operated by Vodafone</td>
</tr>
<tr>
<td>Austria</td>
<td>5G private networks operated by A1 Telekom Austria</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>5G private networks operated by T-Mobile</td>
</tr>
<tr>
<td>Japan</td>
<td>• In 2020, Fujitsu was granted Japan's first commercial Private 5G radio station license from the Kanto Bureau of Telecommunications to operate a Private 5G network at its Shin-Kawasaki Technology Square office.27</td>
</tr>
<tr>
<td></td>
<td>NTT DoCoMo, KDDI and SoftBank and Rakuten Mobile are the MNOs that have received licenses to operate 5G networks in Japan.28</td>
</tr>
</tbody>
</table>
Appendix-IV. Spectrum Prices and Available Spectrum in India

Table III-1. Variation in Reserve and Winning bid prices of spectrum in India
Table III-2. Variation in available and allocated spectrum in India
Available & Allocated spectrum in the 2100 MHz frequency band across time

Available & Allocated spectrum in the 2300 MHz frequency band across time
# Appendix-V. Licensing Guidelines for 6 GHz in different countries

<table>
<thead>
<tr>
<th></th>
<th>De-Licensed</th>
<th>Partially de-licensed</th>
<th>Licensed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6 GHz</strong></td>
<td>• In April, 2020, the FCC in US adopted rules that make 1,200 megahertz of spectrum in the 6 GHz band (5.925–7.125 GHz) available for unlicensed use.</td>
<td>• In July, 2020, Ofcom in UK decided to make the lower 6 GHz band (5925-6425 MHz) available for Wi-Fi and other RLAN devices on a licence-exempt basis, enabling indoor and very low power (VLP) outdoor use. They’re considering the de-licensing of the upper band (6425-7125 MHz).</td>
<td>Countries like Argentina, Oman, Thailand and large parts of Africa are yet to allow any license-exempt use, although de-licensing in these regions is under consideration for the lower 6 GHz band (5925-6425 MHz).</td>
</tr>
<tr>
<td><strong>(5925MHz-7125MHz)</strong></td>
<td>• Other countries that have de-licensed the whole 6GHz band (5925MHz- 7125MHz) include- South Korea, Canada, Brazil, Colombia, Peru, Dominican Republic, Honduras, Costa Rica, Peru, Saudi Arabia.</td>
<td>• In June 30, 2021, the EU de-licensed 480 MHz of (low) 6 GHz spectrum (5945-6425 MHz) to Wi-Fi. They’re considering the de-licensing of the upper band (6425-7125 MHz).</td>
<td></td>
</tr>
<tr>
<td><strong>60 GHz</strong></td>
<td>• In July, 2016, the FCC in US adopted rules to allow for unlicensed operations in the 64-71 GHz band thus creating a contiguous spectrum</td>
<td>• Countries that have allowed license-exempt use of 57-64 GHz band include- Canada, Japan, Singapore, Australia, EU.</td>
<td></td>
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<tr>
<td><strong>(57-71 GHz)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

30  https://6ghz.info/
33  https://6ghz.info/
34  https://www.wi-fi.org/countries-enabling-wi-fi-in-6-ghz-wi-fi-6e
segment with the 57-64 GHz band which was already operating on unlicensed basis.

- In 2018, Ofcom adopted regulations for license-exempt operations in the 57-71 GHz band.

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