Cross-Sectoral Infrastructure Sharing for Broadband

Academy of ICT Essentials
for Government Leaders

UNITED NATIONS ESCAP Economic and Social Commission for Asia and the Pacific / APCICT

The Academy of ICT Essentials for Government Leaders

Cross-Sectoral Infrastructure Sharing for Broadband

ASIAN AND PACIFIC TRAINING CENTRE FOR INFORMATION AND COMMUNICATION TECHNOLOGY FOR DEVELOPMENT

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CROSS-SECTORAL INFRASTRUCTURE SHARING FOR BROADBAND

This module introduces the concept of cross-sectoral infrastructure sharing and how suitable strategies can be leveraged to expand the reach of broadband connectivity to the unserved and underserved living in rural and remote parts of the world. It explores the policy and regulatory issues around infrastructure sharing and explains prevalent models of cross-sectoral infrastructure sharing with illustrative examples.

MODULE OBJECTIVE

The main objective of this module is to foster a better understanding and appreciation of cross-sectoral infrastructure sharing that supports broadband connectivity to reach the unconnected.

LEARNING OUTCOMES

At the end of this module, participants will understand and appreciate the following:

- The increasing importance of information and communication technologies infrastructure in socioeconomic development.
- The benefits of sectoral and cross-sectoral infrastructure sharing for expanding broadband connectivity.
- How the cost of installing broadband can be reduced by sharing existing utilities and coordinating future expansions with them.
- The various approaches for regulation and business models for cross-sectoral infrastructure sharing.
- How the benefits of infrastructure sharing can mitigate apprehension about the unfair competition among operators in the market.
- The concept of open access broadband networks.
- The idea of open access broadband infrastructure as a common utility.
- The various models of sectoral and cross-sectoral infrastructure sharing.
- The idea of cooperation and collaboration among the sectoral players for sectoral and cross-sectoral infrastructure sharing.
- The principles of sharing infrastructure in various sectors and regions.

TARGET AUDIENCES

The target audiences of this module are policymakers and civil servants at the national and local government levels who are responsible for or associated directly or indirectly with telecommunication infrastructure planning and implementation.

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ABBREVIATIONS AND ACRONYMS

1G/2G/3G/4G/5G	First/Second/Third/Fourth/Fifth Generation (of Mobile Communication Standards)
AI	Artificial Intelligence
AP-IS	Asia-Pacific Information Superhighway
APCICT	Asian and Pacific Training Centre for Information and Communication Technology for Development
CapEx	Capital Expenditure
ESCAP	Economic and Social Commission for Asia and the Pacific (United Nations)
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
ITU	International Telecommunication Union
NGN	Next Generation Network
OpEx	Operating Expenditure
OTT	Over-the-Top

1. INTRODUCTION TO INFRASTRUCTURE SHARING

1.1 Introduction

This section begins with an explanation of the infrastructure that lies behind our seamless movements in the world of the Internet. The discussion then moves to the assets that are built, operated and maintained to support the Internet network. Terms that are used throughout the module such as passive and active infrastructures, dark fibre, ducts, towers, aerial cables and optical ground wire are explained.

This section also looks at the history of infrastructure sharing and highlights the common benefits of infrastructure sharing by individual organizations, utilities and sectors. The argument around cost sharing, and the challenges of maintaining the quality of services and the security and resilience of a shared infrastructure are introduced.

This section ends with a discussion on the emerging realities of a networked world. It discusses how advanced technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) are going to be the new normal in the coming decades and why the digital disparities between people, places and nations need to be mitigated by providing the long-haul backbone and last-mile broadband[1] connectivity. The section also briefly discusses broadband as a means to achieve the goals of sustainable development.

1.2 Learning Objectives

At the end of this section, you will be able to:

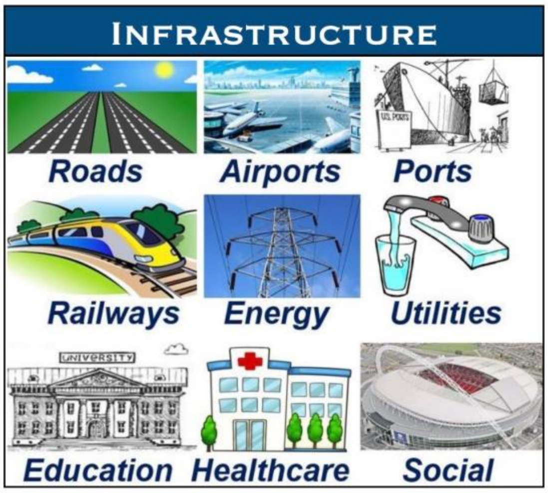
- Highlight the increasing importance of information and communication technologies (ICTs) infrastructure in socioeconomic development.
- Trace the benefits derived from infrastructure sharing over the years and why it is essential for expanding broadband connectivity.
- Understand the potential role of broadband as the lifeline of modern lives and a crucial necessity for socioeconomic activity.

[1] Since broadband technologies are constantly changing, the definition of broadband also continues to evolve. Broadband combines connection capacity (bandwidth) and speed. The ITU defines broadband as: "transmission capacity that is faster than primary rate Integrated Services Digital Network at 1.5 or 2.0 Mbps". The United States Federal Communications Commission specifies that broadband Internet should have a minimum speed of 25 Mbps for downloads and 3 Mbps for uploads.

1.3 Defining Infrastructure and Co-Deployment

The definition of infrastructure has widened in scope over the years. A simple explanation is provided by Merriam-Webster dictionary, which says that: “it is the underlying structure of a country and its economy, the fixed installations that it needs to function”.[2] In other words, infrastructure means those basic facilities and systems that are essential for an individual, household, region or nation to function. It includes railways, roads, bridges, highways, other transport facilities, water supply systems, electricity lines, telephone systems and Internet connectivity. Fulmer defines infrastructure as: “the physical components of interrelated systems providing commodities and services essential to enable, sustain or enhance societal living conditions”.[3]

Figure 1: Different types of infrastructure



Source: Market Business News.

Infrastructure can be categorized into two main types – hard or economic infrastructure and soft or social infrastructure.

Hard or economic infrastructures are basic facilities and services necessary for the functioning of the economy or the industry such as roads, airports, seaports, railways and electricity. These basic amenities are needed for our daily living and are often taken for granted in modern societies. They are also called public utilities as these infrastructures provide water, electricity, natural gas, telephone service and other essential services. Large investment is needed to build these infrastructures. Therefore, these are built either by governments or in partnership with the private sector. People pay for these infrastructure services, although in some cases, governments provide them for free. In India, for example, one can drive along most of the *sarkari* or government-built roads without charge but on some highways, toll fees are collected to cover the cost of construction and maintenance (Case Study 1).

Soft or social infrastructures are the basic facilities and services necessary for every person to live with a minimum standard or dignity of life. In other words, soft infrastructure refers to all the facilities, institutions and services required to maintain the economic, health, cultural and social standards such as educational institutions, hospitals, police and the judiciary. These infrastructures contribute to the economy, for example, the education system provides skilled workers to the industry.

[2] Merriam-Webster, "Infrastructure". Available at https://www.merriam-webster.com/dictionary/infrastructure.
[3] Jeffrey Fulmer, "What in the world is infrastructure?" *PEI Infrastructure Investor* (July/August 2009), pp. 30-32.

Case Study 1: Toll on highways in India

The central government in India, by law, can levy fees for the use of specific ferries, bridges, tunnels or sections of national highways. The government collects user fee (toll) by engaging contractors or allowing a concessionaire to collect toll from users. In India, tolling is generally under an open system, whereby the fee is a fixed amount based on the length of stretch under one project, which is normally 60 kilometres. If a stretch is of lesser length, user fee of actual length is collected. User fee on a particular fee plaza is based on stretch length under that plaza, structures (bridge, tunnel, bypass), width of the highways, applicable fee rules and provisions of the concessions agreement. User fee is also based on the vehicle's size and load it carries, damage done to the road and type of use (commercial/personal) of a vehicle. Concessions to local or frequent users are extended as welfare measures. In some cases, user fee collection is allowed when the project is 75 per cent complete, enabling use of the completed part of the road, and travellers pay only for the completed length opened for traffic. A concessionaire has the right to collect user fee until completion of the concession period allowed under the agreement. Once a highway is built, toll is to be collected to recover the cost. Once cost is recovered, the fee is collected at a reduced rate of 40 per cent for road maintenance.

Source: National Highways Authority of India. Available at http://tis.nhai.gov.in.

In recent years, the term **critical infrastructure** has been introduced to indicate a set of infrastructures such as water, wastewater, power, transportation and telecommunication (or telecom) systems without which buildings, emergency response systems and other infrastructure cannot operate as intended.[4] These interdependent facilities and systems can be considered the backbone of modern existence as our lives depend on them. Critical infrastructures are also essential for the economies and societies to grow and develop. They are so vital to a nation that their incapacity or destruction would have a debilitating effect on national security, the economy, public health and safety.[5] Countries define their critical infrastructure according to their national contexts, needs and priorities, but, in the majority of cases, telecom systems are recognized as critical infrastructure since the operations of many

[4] National Research Council, *Sustainable Critical Infrastructure Systems: A Framework for Meeting 21st Century Imperatives – Report of a Workshop* (Washington, D.C., The National Academies Press, 2009). Available at https://doi.org/10.17226/12638.
[5] Internet Engineering Task Force Security Glossary.

other key infrastructures depend heavily on telecom networks, including the Internet (Box 1).

Box 1: Internet as a critical infrastructure

To successfully rise to the challenges of building and securing reliable cyber-interdependent networks for the delivery of services such as Internet telephony, online banking, trading and payment processing, I argue that we must consider the Internet as critical infrastructure. To complement this view, I recommend the development and adoption of a framework for designing in security and reliability and assessing the readiness of interdependent networks of critical infrastructure.

Reliability and security of networks on the scale of the Internet require significant investments of time, resources and funding. Owing to the private ownership of most Internet delivery resources, and the competition in the Internet access market and the services delivered over it, public and private cooperation is required in defining and implementing a framework for the construction, security and assessment of these critical infrastructures and key resources. In addition to the regulatory oversight needed to ensure reliable and secure operation of these key resources, business models are needed that recognize the value of reliability and security in the delivery of essential services over the Internet.

Considering the maturation of the Internet into a delivery vehicle for essential communications, and financial, trading and broadcast services, the complexities of designing reliable and secure interdependent networks of critical infrastructure, and the increase in the volume and sophistication of cyberattacks as well as natural disasters, the Internet must become broadly recognized as critical infrastructure. To do so would represent an opportunity for the industry, researchers and regulators to cooperate to ensure the reliable and secure operation of the future Internet.

Source: Extracted from Walter Miron, “Should the Internet be considered critical infrastructure?” *Technology Innovation Management Review*, January 2015.

In infrastructure sharing, partners agree to share their infrastructure to increase cost-effectiveness and competition, and provide affordable access to ICT services. Infrastructure sharing includes sharing technological expertise and best practices, and helps spread next generation networks (NGNs) at national, regional and international levels.[6] The traditional vertically-integrated companies or entities offering ICT services at various levels are now giving way to partnerships where several actors join hands to roll out ICT services. In such a sharing arrangement, one party may offer the ducts to lay the cables, another will set up towers, and another may offer their dark fibres. Together, all the partners try to make ICT services available and affordable to the end users.

On the other hand, co-deployment focuses on the planning and implementation of telecom networks and equipment, especially laying the fibre-optic cables at the time of construction of various facilities. For instance, while constructing roads, setting up power transmission lines, building railway tracks or other utilities, attention is paid to deploy fibre-optic cables simultaneously. Co-deployment reduces cost, minimizes damages to infrastructure and avoids disruptions that occur when cables are deployed separately (e.g., by digging on an existing road). The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) defines such co-deployment as: "concomitant deployment of ducts and fibre-optic cables during the construction of infrastructures such as new roads, highways, railways, power transmission lines and oil/gas pipelines".[7]

Infrastructure sharing and co-deployment need advance planning, regulatory support, mutual understanding among the actors about cost and revenue sharing, operation and maintenance, and overall feasibility of implementation. Infrastructure sharing requires greater coordination among several actors at different levels over time, whereas co-deployment is a part of the construction process or the setting up of the facilities.

Although there is increased acceptance of the benefits of infrastructure sharing by sectoral players, implementing sharing arrangements, reorienting sectoral regulatory mechanisms and executing co-deployment projects – all need an approach to coordinate across the sectors efficiently. It needs political commitment at the highest level to bring all sectoral players to the table to see the cumulative advantages of sharing in expanding broadband coverage and its overall contribution to a nation's socioeconomic advancement. While the ICT sector can anchor such a national plan, it is necessary to have a national umbrella platform to ensure coordination and cooperation among line ministries, regulators and sectoral players.

It is important to note that the interdependency of infrastructures is critical today. A disruption will invariably affect the others and may even jeopardize the entire system in a chain reaction. Within this interdependency lies the inherent nature of sharing among various infrastructural installations. In smart cities,[8] these are more proactively planned and shared, not only in terms of hardware but also in terms of software that

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[6] ITU, "All About Infrastructure Sharing", July 2018. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/All_About_InfrastructureSharing_2018.pdf.

[7] ESCAP, "Toolkit for ICT Infrastructure Co-Deployment with Road Transport and Energy Infrastructure Part II", Asia-Pacific Information Superhighway (AP-IS) Working Paper Series, March 2020. Available at https://www.unescap.org/sites/default/files/Toolkit_codeployment_ids.pdf.

[8] A smart, sustainable city is an innovative city that uses ICTs and other means to improve quality of life, the efficiency of urban operation and services and competitiveness while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects. Source: ITU, "Focus Group on Smart Sustainable Cities". Available at http://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx.

includes information sharing among the operators of these infrastructures. It is within this overarching sharing approach that infrastructure sharing takes place across various facilities and systems. Hence, telecom cables can ride along power grid networks, and the optical fibre installed by a railway can be shared by telecom operators to provide Internet services. When railway and telecom operators agree to share their existing infrastructures, serving more people at less cost is possible. Moreover, when these infrastructures belonging to different sectors are installed together or co-deployed, it saves construction costs for both.

In infrastructure sharing, a distinction is made between **active** and **passive** infrastructure. An infrastructure owner or operator can make some parts of its facilities available to others for use without hampering its main operations. The essential parts of the infrastructure to main activities or services can be called active, while the parts of the infrastructure that can be shared with others can be called passive. For example, in the telecom sector, active infrastructure includes key electronic components such as antennas, feeder cables, nodes, radio access networks, transmission systems and backhaul. Passive infrastructure sharing means sharing the non-electronic infrastructure such as buildings, sites, masts, ducts, towers and dark fibre (the unutilized part in a fibre-optic network).

Traditionally, major infrastructure like towers is built and operated by telecom companies. With increasing competition in the sector, tower companies or Towercos are growing in countries like India, Indonesia, Malaysia and Viet Nam. While Towercos will lend their services to multiple telecom companies to maximize their earnings, telecom operators may find it more profitable not to allow competitors to use their infrastructures.[9] However, shared infrastructure is emerging as a major enabler for telecom operators to expand their connectivity in remote and low-income areas. Shared infrastructure can help reduce the cost of ICT connectivity by reducing the cost of building infrastructure for potential operators. In Myanmar, mobile broadband prices reduced drastically after transferring 1,250 towers from Digicel to the tower company, Edotco.[10]

The demand for fibre-optic connection is increasing with the demand for greater bandwidth and faster Internet. The costs and challenges of installing underground fibre-optic cable prevent many service providers from reaching out to remote areas and rural communities. An alternative solution is to use existing overground structures to mount **aerial fibre-optic cables** to build fibre-to-the-home networks to connect the end user. It is cost-effective and especially useful in hilly regions. It can also be adopted as a stop-gap arrangement until a full-fledged underground network is laid out. Although potentially more vulnerable to physical damage and service disruptions, aerial cables can save 80-90 per cent in cost compared to underground installations.[11]

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[9] ITU, "Digital Infrastructure Policy and Regulation in the Asia-Pacific Region", September 2019. Available at https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/RRITP2019/ASP/ITU_2019_Digital_Infrastructure_5Sep2019FNL.pdf.

[10] Davide Strusani and Georges V. Houngbonon, *Accelerating Digital Connectivity Through Infrastructure Sharing*, EMCompass no. 79 (Washington, D.C., International Finance Corporation, 2020). Available at https://openknowledge.worldbank.org/handle/10986/33616.

[11] Tobias Schubert, "How aerial cable deployment can drive broadband expansion", *Telecom Review*, 12 May 2020. Available at https://www.telecomreview.com/articles/reports-and-coverage/3885-how-aerial-cable-deployment-can-drive-broadband-expansion.

Another avenue for infrastructure sharing is the use of **optical ground wire,** which is also called optical fibre composite overhead ground wire according to the Institute of Electrical and Electronics Engineers (IEEE) standard.[12] These cables are installed in electric power transmission lines and distribution networks. The optical ground wire cable serves as a grounding for the power lines and carries ICT services through the optical fibre built into the wire.

For example, in Bhutan, optical ground wire cables were laid along power transmission lines between Thimphu and Phuentsholing, ultimately connecting to the submarine cable for international connectivity through India. Bhutan Telecom Limited and Bhutan Power Corporation shared the infrastructure. Later, all the fibre assets of Bhutan Telecom Limited and Bhutan Power Corporation were consolidated following an executive order issued by the Government of Bhutan and an agreement between the government and Bhutan Power Corporation to execute the National Broadband Master Plan Implementation Project. Subsequently, licensed operators were allocated a pair of dark fibres without any lease charge[13] (Case Study 2).

Case Study 2: Optical ground wire in Bhutan

In Bhutan, the Ministry of Information and Communications has invested heavily in executing the National Broadband Master Plan Implementation Project to establish an optical fibre backbone network throughout the country. The project has connected 18 *dzongkhags* (districts) with optical ground wire cables and the remaining two *dzongkhags* and 201 *gewogs* (group of villages) with all-dielectric self-supporting cables. The national fibre network is operated and maintained by the Bhutan Power Corporation. The government has provided a pair of dark fibres to telecom service providers and Internet service providers for free with the intention to ensure affordable telecom and Internet services for end users.

Source: Ministry of Information and Communications, Government of Bhutan, “Press Release: National Fiber Monitoring System”, 13 July, 2018. Available at https://www.moic.gov.bt/en/category/press-release/.

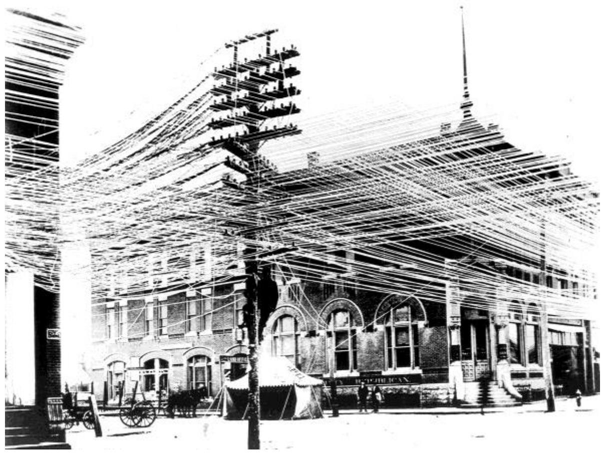
[12] The IEEE develops global standards for a broad range of sector including ICT, power and energy, among others.
[13] ESCAP, "ICT Co-Deployment with the Electricity Infrastructure: The Case of Bhutan", Asia-Pacific Information Superhighway (AP-IS) Working Paper Series, June 2019. Available at https://www.unescap.org/resources/ict-co-deployment-electricity-infrastructure-case-bhutan.

1.4 History of Infrastructure Sharing

The history of telecommunication[14] began with infrastructure sharing in 1843 when the British inventor, William Cooke, collaborated with Great Western Railway to use telegraph services for railway signalling. Later, the service was open to the public to use the same telegraph infrastructure for payments.[15] Samuel Morse was doing the same in the United States of America where he was using the railway corridor to install poles and lines to offer telegraph services to the public for a fee, but it was free for the railway operator. This sharing of railway corridor continued over the years and across continents, providing a familiar image of telegraph and telephone lines running side by side along railway tracks. The choice of railway corridor for erecting telegraph and later telephone lines was mutual as railways had offices in prime locations, fewer obstructions than roads, and easy availability of last-mile transport facility to carry messages from telegraph stations to the receivers.

As time passed, similar sharing of corridors and facilities between the telecom system and other infrastructure systems such as railways, roads and electricity continued.[16] Although initially, the railway operators were sceptical about the benefits of sharing their rights of way and other infrastructures like offices, they gradually saw that infrastructure sharing helped them in their operational communications. This realization led to the further growth of the telegraph along the railway tracks. By the early nineteenth century, telegraph became a universal service, but telephone was becoming more popular in the decades that followed. In the initial years of their co-existence, the telegraph and telephone services served different markets – telegraph for long-distance communications and telephones for more local communications where users could talk among themselves directly. Both telegraph and telephone lines used iron wires that were mounted on poles. As telephone services needed more customers on a network for its usefulness, the number of wires and poles continued to increase (Figure 2). These telephone lines were open to damage, breaks and service disruptions due to natural calamities and weather conditions. To improve the

Figure 2: Maze of wires in Pratt, Kansas, United States of America, 1900



Source: Perce Cox. Available at https://www.beatriceco.com.

[14] Telecommunication, from a historical perspective, refers to transmission of information by various types of technologies over wire, radio, optical or other electromagnetic systems.
[15] Russell W. Burns, *Communications: An International History of the Formative Years* (London, Institute of Engineering and Technology, 2004).
[16] Anton A. Huurdeman, *Worldwide History of Telecommunications* (New York, J. Wiley, 2003).

service, this clutter of wires needed to be installed underground and city administrators were mandating that the wires be buried.[17]

With the need to reduce the clutter, multiple wires were bundled into cables to take less space when installed on poles. These cables were insulated, and hence they could be mounted on electricity poles without any immediate risk of electric interference. This ushered in a new era of infrastructure sharing between electricity and telephone companies – the genesis of a modern-day utility pole that supports a host of public utilities such as electricity, telephone and cable television networks. When the cost of burying cables became high, it was economical to mount the cables over existing poles of other utilities like electricity. However, telephone cables were expensive and needed a substantial number of users to justify the installations of cables. Hence, in developing countries like India, the open uninsulated telephone lines continued to stay, and they stood separate from electricity poles.

Interestingly, the growth of wireless communication and development of microwave technology in the second half of the twentieth century reduced the need to share infrastructure as wireless was cheaper than cable installations over long distances. The need for infrastructure sharing was further reduced with the emergence of satellite communication technology. Remote areas were much more effectively being covered by communication systems without laying down expensive underground cables to cover difficult terrains and smaller user communities. Many developing countries started to use satellite-based communication systems instead of landline telephones.[18] However, high latency[19] or delay in transmission made satellite-mediated communication obsolete although they remained useful for covering remote, isolated populations and for emergency communications.[20]

Mobiles phones were available around as early as 1946, but in the 1980s, the first generation (1G) cellular-based advanced mobile phone system technology brought the affordable mobile phone to the world.[21] The mobile phone system did not need extensive wire installations and hence depended less on physical infrastructures. Subsequent developments in digital cellular telephones (second generation or 2G) continued the march of wireless and the need for infrastructure sharing decreased further. Meanwhile, the existing traditional telegraph, landline telephone and cable television networks continued the cross-sectoral infrastructure sharing with other networks such as railways, roads and electricity utilities.

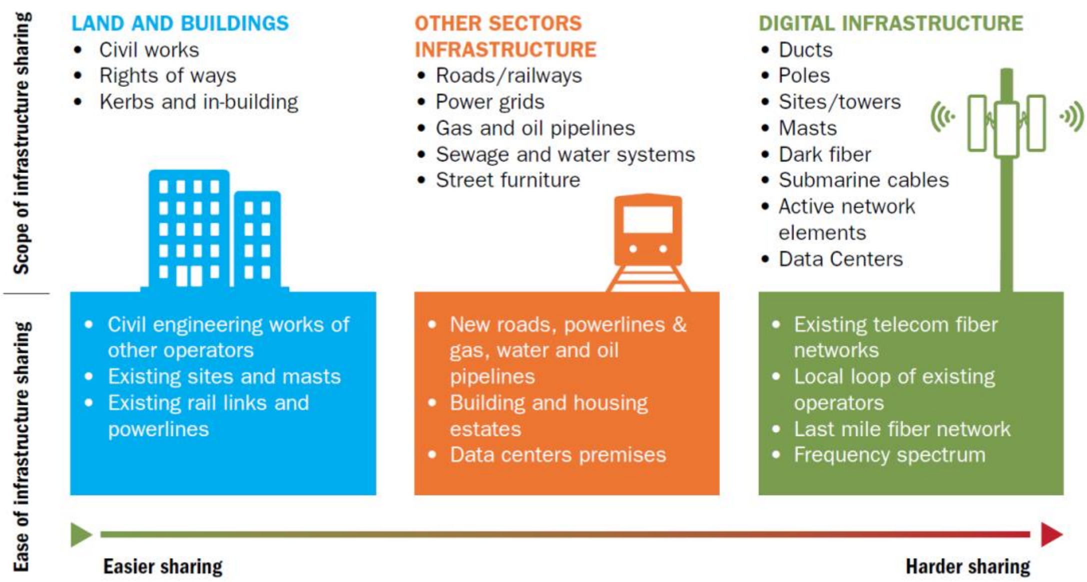
The popularity of mobile phones increased demands for faster transmission of voice and data. This gave rise to the fibre-optic cable technology that gradually started

[17] Ken Beauchamp, *A History of Telegraphy* (London, Institution of Engineering and Technology, 2001).
[18] M. K. Luka and others, “Satellite Communications: Impact on Developing Economies”, *Journal of Emerging Trends in Computing and Information Sciences*, vol. 2, no. 11 (2011), pp. 574-579.
[19] Latency can be defined as the time it takes for a request (data packet) to travel from the sender to the receiver.
[20] LIRNEasia, "Best use of a regional satellite is not for telecom but for digital broadcasting", 10 September 2015.
[21] Anton A. Huurdeman, *Worldwide History of Telecommunications* (New York, J. Wiley, 2003).

replacing microwave backhaul[22] worldwide in the 1980s.[23] Instead of microwave links, terrestrial fibre-optic networks were being installed as the national backbone, and undersea fibre-optic cables were replacing the satellite-mediated links. The use of fibre-optic cables increased with rising demands for data transmission through broadband networks and for high-speed Internet services. This growing use of fibre-optic cables brought back the need for space to lay the cables. Once again, the benefits of cross-sectoral infrastructure sharing came to the forefront, especially from the cost-saving perspective. Deployment of cables once again looked towards rights of way available with other utilities like railways and roads, poles of power transmission grids, water and gas pipes, and even sewerage lines.[24]

The idea of sharing for mutual benefits that started with railways and telegraph has now entered a much more congested and contested space where infrastructure sharing is no longer a choice but a necessity. Opportunities for sharing across sectors have multiplied with varying degrees of challenges and scopes (Figure 3).

Figure 3: Opportunities for infrastructure sharing



Source: Davide Strusani and Georges V. Houngbonon, *Accelerating Digital Connectivity Through Infrastructure Sharing*, EMCompass no. 79 (Washington, D.C., International Finance Corporation, 2020). Available at https://openknowledge.worldbank.org/handle/10986/33616.

[22] Backhaul refers to the part of the network that communicates with the global Internet. A backhaul of a mobile network connects a cell site with the core network.

[23] John Powers, *An Introduction to Fiber Optic Systems* (McGraw-Hill, 1993).

[24] Jey K. Jeyapalan, "Sharing pipelines, tunnels, multipurpose structures, and rights of way among cables, gaslines, sewers, heating ducts, and waterlines", paper presented at the 7th International Conference on Power Insulated Cables, Versailles, 25-28 June 2007.

1.5 Future of the Networked World

Digital technologies sustain life, work, health and learning for billions of people, yet half the world's population remains unconnected to the Internet.

António Guterres
Secretary-General of the United Nations

Advancement in ICTs, and the increasing capacity to collect, store, process and disseminate data faster with decreasing hardware and software costs have created a networked world. More than ever, we are becoming increasingly dependent on globally interconnected infrastructures to run even basic activities. All aspects of modern-day life, transportation, health care, entertainment, work, businesses, social interactions and governance are being bundled together through complex systems that rely on converged and ubiquitous infrastructures.[25]

In this networked world, the availability of fast and affordable ICT connectivity is placed at the centre of the 2030 Agenda for Sustainable Development in the Asia-Pacific region.[26] ICTs supported by reliable broadband connectivity are the new drivers of economic growth, increased productivity and efficiency. Broadband access is seen as a foundation for the digital economy and society across socioeconomic sectors, including health, education, financial services, business, trade, transport, smart agriculture and energy systems, just to name a few.[27]

In 1999, Kevin Aston, a prominent British technologist, introduced IoT to depict an emerging world where billions of physical devices are connected through the Internet, allowing them to draw data through sensors and respond automatically without human intervention.[28] This network of physical devices that can respond to a set of data by leveraging digital intelligence marks the new reality. Starting with basic home utilities like switching on the lights in a home at a distance through a mobile application to controlling a driverless car or aircraft – all can be part of the IoT where devices make smart decisions based on the data provided through the network. Smart cities will be full of sensors that will be used to guide traffic, monitor the environment, control streetlights and perform many other functions. The IoT depends on robust, reliable and seamless ICT connectivity, hence there will be increasing demand for broadband Internet connectivity.

AI can be combined with IoT to present what is called the Artificial Intelligence of Things, in which IoT devices make up the digital nervous system while AI is the brain

[25] Rashid Mehmood and others, "Smart Societies, Infrastructure, Technologies and Applications: Proceedings of the First International Conference", SCITA 2017, Jeddah, Saudi Arabia, November 2017.
[26] ESCAP, "Concept Note: Subregional Capacity Development Workshop on ICT Co-deployment along Transport Infrastructure in East and North-East Asia Subregion, Ulaanbaatar, Mongolia", 20 November 2019. Available at https://www.unescap.org/sites/default/files/Concept%20Note%20%26%20Draft%20Agenda_0.pdf.
[27] Ibid.
[28] Thorsten Kramp, Rob van Kranenburg and Sebastian Lange, "Introduction to the Internet of Things", in *Enabling Things to Talk*, A. Bassi and others, eds. (Berlin, Heidelberg, Springer, 2013). Available at https://doi.org/10.1007/978-3-642-40403-0_1.

of the system.[29] If devices in IoT are responding to data, AI enables them to analyse the data and make smart decisions themselves. It can be called a replica of human intelligence where machines respond and perform activities like sifting through a set of data and solve a given problem. The World Bank's *World Development Report 2019* discusses the changing nature of work and argues that advanced technologies like AI will change the way of doing things and create opportunities for people who can acquire new skills and leverage these technological developments.[30] In other words, the prevalent environment of production, employment, productivity and economic activities will drastically change over the coming years. The broader picture that is gradually emerging is that of a world increasingly dependent on components that include broadband connectivity.[31]

While all these technological developments are becoming a reality faster than we have imagined, the issue of uneven access to broadband connectivity comes to the forefront. Despite encouraging development in mobile broadband, over half of Asia-Pacific's population still do not have access to broadband.[32] The digital disparity between and within countries in the region is becoming more visible with the gaps between developed and developing countries and between urban and rural areas widening.[33]

Accelerated efforts to narrow the digital divide between and within countries are urgently needed, and infrastructure sharing to expand broadband connectivity is a proven approach. Many success stories have emerged from various parts of the world demonstrating how passive infrastructures such as roads, railways, power grids, and oil and gas pipelines can be used to roll out broadband connectivity to wider areas.

[29] Bernard Marr, "What is the Artificial Intelligence of Things? When AI Meets IoT", *Forbes*, 20 December 2019. Available at https://www.forbes.com/sites/bernardmarr/2019/12/20/what-is-the-artificial-intelligence-of-things-when-ai-meets-iot/?sh=3a84d2cfb1fd.
[30] World Bank, *World Development Report 2019: The Changing Nature of Work* (Washington, D.C., 2019).
[31] ESCAP, *Artificial Intelligence and Broadband Divide: State of ICT Connectivity in Asia and the Pacific* (Bangkok, 2017). Available at https://www.unescap.org/sites/default/files/StateofICT2017_16Jan2018.pdf.
[32] Ibid.
[33] ESCAP, "Measuring the Digital Divide in the Asia-Pacific Region for the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)", Asia-Pacific Information Superhighway (AP-IS) Working Paper Series, October 2019. Available at https://www.unescap.org/resources/measuring-digital-divide-asia-pacific-region-united-nations-economic-and-social-commission.

1.6 Summary

The term infrastructure brings up images of huge physical constructions that traverse our landscapes. It refers to an underlying framework that supports many facilities and amenities, collectively called systems, that modern societies depend upon to develop their economies and drive growth.[34] Telecom infrastructures are no exception as telephone, mobile and Internet networks are also systems that economies and societies depend on to function. Historically, there have been many instances of infrastructure sharing since the days of the telegraph, and this sharing approach has become more crucial with the roll out of ideas like smart cities that are run by shared networks.

The ICT infrastructure, specifically broadband connectivity, plays a crucial role in achieving the 2030 Agenda for Sustainable Development in the Asia-Pacific region. Broadband connectivity can drive innovation, boost productivity and increase efficiency, which can, in turn, bring the desired socioeconomic development. Broadband can also connect, interact and influence all sectors, including health, education, financial services, agriculture, energy, commerce and industry.

However, as the expansion of broadband connectivity is expensive, especially in small and remote communities, cross-sectoral infrastructure sharing and co-deployment of fibre-optic cables with other utilities such as roads and railways, power grids and oil and gas pipelines, can save installation and maintenance costs, and more areas can be covered. Infrastructure sharing to expand broadband connectivity can benefit those involved in sharing, especially for leveraging advanced technologies like AI and IoT.

Cross-sectoral infrastructure sharing has its planning, implementation, financial regulatory and operational challenges. There are issues related to the economic viability and policy contexts of the countries. But there are also success stories and encouraging examples to learn from where these issues have been addressed. Based on this understanding, we can chart our plans for the future.

[34] Brett M. Frischmann, *Infrastructure – The Social Value of Shared Resources* (Oxford and New York, Oxford University Press, 2012).

1.7 Exercise: Check Your Progress

Answer the following:

1. Literally, “infrastructure” means ____________________ structure.
2. Hard infrastructure are those basic facilities and services that are necessary for the functioning of the ___________________.
3. Basic amenities needed for our daily living are also called public _________________.
4. Critical infrastructure can be called the _________________ of modern life.
5. Smart cities not only share hardware but also share ________________ among the infrastructure operators.
6. If infrastructures belonging to different sectors are installed together or “co-deployed” it saves __________________ costs for both.
7. Demand for fibre-optic connection is increasing because of the demand for _____________________.
8. Optical ground wire is installed in ___________________________ lines.
9. To reduce the clutter of multiple wires, telephones were bundled into ______________.
10. Development of microwave technology in the second half of the twentieth century _______________ the need to share infrastructure.
11. Popularity of mobile phones increased demands on the networks for faster transmission of voice and __________________.
12. Fibre-optic cable technology gradually started replacing __________________ backhaul around the world in the 1980s.
13. IoT leverages _________________ intelligence.
14. AI can be called a replica of ___________ intelligence.
15. Accelerated efforts to ______________ the digital divide between and within countries are urgently needed to expand broadband connectivity.

1.8 Suggested Readings and Online Resources

1. Frischmann, Brett M. (2012). *Infrastructure – The Social Value of Shared Resources*. Oxford/New York: Oxford University Press.
2. Fulmer, Jeffrey (2009). What in the world is infrastructure? *PEI Infrastructure Investor* (July/August), pp. 30–32. Available at https://30kwe1si3or29z2y020bgbet-wpengine.netdna-ssl.com/wp-content/uploads/2018/03/what-in-the-world-is-infrastructure.pdf.
3. Hamutuk, Luta (n.d.). Civil society comments on the infrastructure strategic sector. Available at https://www.laohamutuk.org/econ/14TLDPM/InfraCSOen.pdf.
4. Kramp, Thorsten, Rob van Kranenburg and Sebastian Lange (2013). Introduction to the Internet of Things. In *Enabling Things to Talk*, A. Bassi and others, eds. Berlin, Heidelberg: Springer. Available at https://doi.org/10.1007/978-3-642-40403-0_1.
5. Strusani, Davide, and Georges V. Houngbonon (2020). *Accelerating Digital Connectivity Through Infrastructure Sharing*. EMCompass no. 79. Washington, D.C.: International Finance Corporation. Available at https://openknowledge.worldbank.org/handle/10986/33616.

2. ADVANTAGES AND ECONOMICS OF INFRASTRUCTURE SHARING

2.1 Introduction

Section 1 broadly discussed the meaning of infrastructure and how infrastructure sharing among various utilities has evolved. The section ended with a description of the emerging convergence of a networked world where smart cities will depend heavily on sharing the physical infrastructures and data through advanced technologies like AI and IoT. All these need broadband connectivity that must be available to all.

This section begins with a discussion on the planning, design and cost of building infrastructure and how, in the absence of an integrated approach, duplication of efforts and expenditures adversely impact not only the sectoral operators but also the limited financial resources of a nation. The section highlights the advantages of cross-sectoral infrastructure sharing in terms of revenue, services, expansion, affordability and quality.

This section also explains the economics and opportunities of infrastructure sharing between telecommunication and other sectors like power, roads and railways. With the help of case studies concerning capital expenditure (CapEx) and operating expenditure (OpEx), this section explains how the high cost of deploying broadband infrastructure can be reduced by using existing utilities and coordinating future expansions with them, thereby reducing cost of services for the end user and the operators. This section argues that the benefits of infrastructure sharing far outweigh the apprehension about the unfair competition (market distortion) among operators.

2.2 Learning Objectives

At the end of this section, you will be able to:

- Explain how an integrated approach in infrastructure building can avoid duplications and save financial resources.
- Highlight the advantages of cross-sectoral infrastructure sharing.
- Understand how the cost of installing broadband can be reduced by sharing existing utilities and coordinating future expansions with them.
- Analyse how the benefits of infrastructure sharing can mitigate the apprehension about the unfair competition among operators in the market.

2.3 Approaches to Sharing Infrastructure

Governments, industries and ICT companies are all looking for ways to reduce the cost of deploying infrastructures, and infrastructure sharing is one approach.

In Bangladesh, mobile phone operator, Grameenphone, has been sharing the fibre-optic network of Bangladesh Railways since 1997 when Grameenphone won an international bid to use, maintain and run the business operation of Bangladesh Railways' fibre-optic network. They have been jointly expanding the network since.[35] In 2016, the government took an initiative to enable other telecom operators to lease the unused portion of the fibre-optic network.[36] Grameenphone is ready to share its transmission network – optical fibre and microwave – with other telecom licensees. It is also ready to share its 15,000 sites and passive infrastructure like towers, masts, common room space, equipment shelter, generator room, cooling system and power supply.

In Kazakhstan, the Kazakhstan Electricity Grid Operating Company established Energoinform, which is licensed to provide telecom services. The winding of fibre-optic cables around power transmission lines is a cost-effective technique used in Kazakhstan. These are available for lease by telecom operators at a much lower cost than deploying separate fibre-optic cables, enabling telecom operators to expand their networks across the country.[37]

The advantages of cross-sectoral infrastructure sharing, especially to expand broadband access, are manifold. The cost of infrastructure building is shared among partners, and saved funds can be used to expand the network. New entrants to the market can start offering services without investing heavily in expensive infrastructure. In turn, they can bring competition that will reduce the price of connectivity for the users. It will also reduce duplication of infrastructures and contribute to environmental sustainability.[38] The cumulative impact of these partnerships can increase the use of broadband connectivity for economic growth and social development across the world.[39] These economic and social benefits should drive all stakeholders towards infrastructure sharing (Figure 4).

[35] Muhammad Zahidul Islam, "Railway's fibre optic network to open up to all telcos", *The Daily Star*, 20 December 2016. Available at https://www.thedailystar.net/business/railways-fibre-optic-network-open-all-telcos-1332418.

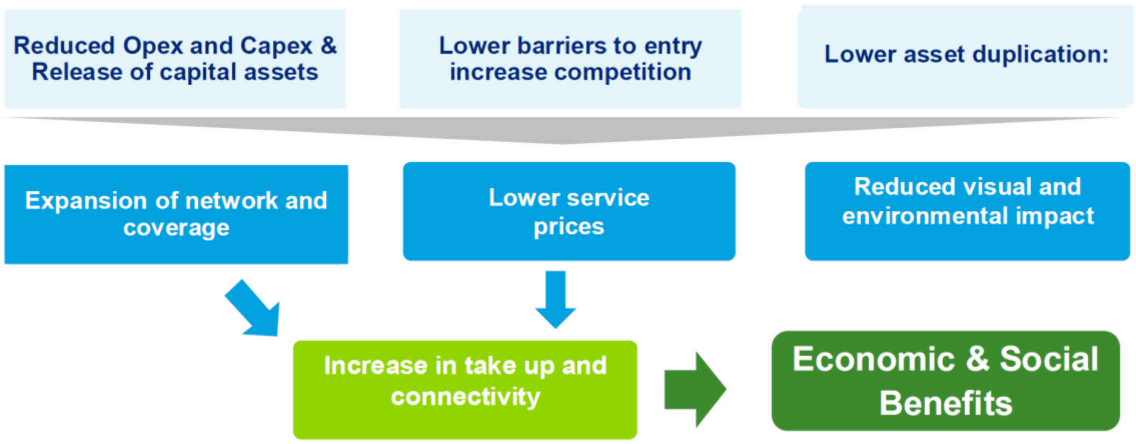
[36] H.M. Murtuza, "GP to get 63pc of proceeds from BR's fibre lease to 3rd party", *New Age Business*, 25 April 2018. Available at https://www.newagebd.net/article/39855/gp-to-get-63pc-of-proceeds-from-brs-fibre-lease-to-3rd-party.

[37] ESCAP, "ICT Infrastructure Co-Deployment with Transport and Energy Infrastructure in North and Central Asia", Asia-Pacific Information Superhighway (AP-IS) Working Paper Series, February 2020. Available at https://www.unescap.org/resources/ict-infrastructure-co-deployment-transport-and-energy-infrastructure-north-and-central.

[38] Deloitte and Association for Progressive Communications, "Unlocking Broadband for All: Broadband Infrastructure Sharing Policies and Strategies in Emerging Markets", April 2015. Available at https://www.apc.org/en/pubs/unlocking-broadband-all-broadband-infrastructure-s.

[39] ITU and UNESCO, *The State of Broadband 2020: Tackling digital inequalities - A decade of action* (Geneva, 2020). Available at https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.21-2020-PDF-E.pdf.

Figure 4: Advantages of infrastructure sharing



Source: Deloitte and Association for Progressive Communications, "Unlocking Broadband for All: Broadband Infrastructure Sharing Policies and Strategies in Emerging Markets", April 2015. Available at https://www.apc.org/en/pubs/unlocking-broadband-all-broadband-infrastructure-s.

The potential benefits of infrastructure sharing can be summarized as follows:[40]

- Sharing of deployment costs, leading to faster and wider coverage and higher quality.
- Sharing of operational costs, leading to lower prices.
- Enhanced competition, benefiting consumers in terms of lower prices.
- Facilitated entry for third-party operators.

Infrastructures have been shared by utilities like railways, roads, water, power and telecommunication at different times and levels through different arrangements. These can be seen as situational or circumstantial endeavours by various departments. However, in the emerging environment of a networked world that is heavily dependent on broadband connectivity, infrastructure sharing among the sectoral players cannot be incidental or one-off experiments. Rather, infrastructure sharing should be well planned and supported by a long-term vision of the emerging nature of the digitalized world. It needs an integrated approach and policy and regulatory support for collaboration at every stage of infrastructure deployment. It should be seen as an economic advantage to share costs and as a necessity to increase productivity and economic growth.

Traditional partnerships for covering segments of the networks by different infrastructure owners to provide connectivity, particularly in reaching the last mile, is now giving place to new models where a common facility is operated by all partners involved (mutualization) or the sectoral operators can join hands to expand new

[40] Marc Bourreau, Steffen Hoernig and Winston Maxwell, "Implementing co-investment and network sharing", *Centre on Regulation in Europe*, 2020. Available at https://cerre.eu/wp-content/uploads/2020/05/cerre_implementing_co-investment_and_network_sharing-26.05.2020_1.pdf.

infrastructure (cooperative).[41] In both cases, an integrated approach is needed to encompass the following five major dimensions of infrastructure sharing (Figure 5):[42]

- **Technology** – Infrastructure sharing needs technological compatibility so that the partners can leverage the mutual benefits. With the advancement in technologies (3G, 4G, 5G, etc.), operators can see the incremental value addition that can be achieved. For example, the telecom arm of Indian Railways, RailTel, is partnering with cable television networks to provide high-speed Internet in rural areas.[43]

- **Geography** – Location is an important factor in infrastructure sharing. The benefits of infrastructure sharing are obvious in congested urban areas where space is not available. In remote areas, the small number of users will demand that existing infrastructures be used to expand services.

- **Architecture** – The scope of infrastructure sharing depends on the combination and compatibility of both active and passive architecture between two owners or operators. While passive infrastructure like utility poles and ducts is easier to share, sharing active architecture like electronic networks needs closer technological viability.

- **Partners** – Different infrastructure owners or operators can come together for intra-sectoral or inter-sectoral sharing. Invariably they follow some regulatory mechanisms, and any infrastructure sharing arrangement will need regulatory mechanisms and authorities to support such sharing. It becomes a challenge when two potential partners have to follow two divergent regulatory mandates.

- **Sourcing** – In modern operations, sourcing (both traditional and strategic) is an important factor for offering services in a competitive market. Hence, the selection of the most suitable sourcing option (e.g., special purpose vehicle, joint venture, public-private partnership) must be carefully considered in any infrastructure sharing scenario.

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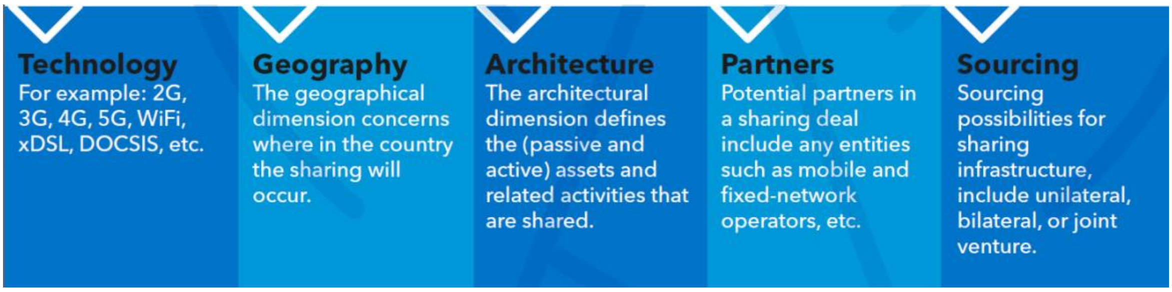
[41] Jose Marino Garcia and Tim Kelly, “The economics and policy implications of infrastructure sharing and mutualisation in Africa”, Background Paper for the World Development Report, World Bank, November 2015. Available at https://thedocs.worldbank.org/en/doc/533261452529900341-0050022016/original/WDR16BPInfrastructureMutualisationGarcia.pdf.
[42] Communications Regulators’ Association of Southern Africa and ITU, “ICT and Broadcasting Infrastructure Sharing Guidelines”, 21 February 2016. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/CRASA-ITU-IS_Guidelines_Final_Jan2018.pdf.
[43] RailNews, "RailTel partners with Cable TV operators to bridge Digital Divide", 30 November 2013. Available at http://www.railnews.in/indias-railtel-partners-cable-tv-operators-to-bridge-digital-divide/.

Figure 5: Five dimensions of infrastructure sharing



Source: Communications Regulators' Association of Southern Africa and ITU, "ICT and Broadcasting Infrastructure Sharing Guidelines", 21 February 2016. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/CRASA-ITU-IS_Guidelines_Final_Jan2018.pdf.

Considering the five dimensions discussed above, the scope of infrastructure sharing will vary. It is much easier to share infrastructure if the new plans for construction include provisions for deployment (or co-deployment) of fibre-optic cables to expand broadband networks. Modern designs of roads, power lines, gas, water and sewerage installations can keep provisions for ducts that telecom operators can use by paying rental charges. On the other hand, it is not as easy to share infrastructures at the local loop level among existing operators.

In between these two scenarios, existing infrastructures of different sectors can be utilized for broadband expansion depending on regulatory arrangements and mutually agreeable business plans. However, strong collaboration is needed, and wherever possible, strategic ICT plans are to be developed based on the needs and emerging technologies that favour infrastructure sharing. Governments and national regulators need to step in where an incumbent poses some challenges to infrastructure sharing. For example, the state of Maharashtra in India is creating a futuristic fibre-optic network that is declared an "important public purpose" project. The state government has allowed the use of all existing infrastructure for deploying fibre-optic cables – no additional charges are required to be paid to the local bodies.[44]

Sectoral infrastructure owners also need better communication facilities for their own operational purposes. In the initial days of launching telegraph services, railway corridors were used, which in turn, helped railway operators maintain better communication to run the trains. That tradition still lives in countries like Bangladesh and India where railway operators have established their own fibre-optic networks that they are now sharing with telecom operators. Similarly, other sectors have realized that it is mutually beneficial to share infrastructures, especially for expanding the broadband networks that they can use themselves, as in the case of Bhutan's power sector. The key opportunities for cross-sectoral infrastructure sharing are presented in Table 1.

[44] Tele.net, "State Initiatives", August 2019. Available at https://tele.net.in/1139-2.

Table 1: Opportunities for cross-sectoral infrastructure sharing

ROADS	PIPELINES (GAS, OIL, WATER)
Provision of ducts for future deployment of fibre-optic cables	Deployment of fibre-optic cables along pipelines
ELECTRICITY GRID POWER LINES	**UTILITY POLES**
Long-distance deployment of fibre-optic cables (invariably with optical ground wire)	Local distribution of fibre-optic cables to homes
RAILWAYS	**SEWAGE PIPES**
Fibre-optic cables deployment along railroads for establishing backbone	Taking the fibre-optic cables to the homes/end users

Source: Natasha Beschorner, "Smart Connections for All: Transport and ICT Global Practice", presentation made at the Asia-Pacific Information Superhighway Steering Group Meeting in Bangkok, Thailand, on 12 December 2017.

Despite the potential benefits of infrastructure sharing in expanding broadband connectivity, there are some challenges, such as the lack of acceptable revenue sharing models, diverse nature of institutional regulatory mechanisms, insufficient funds, missing structures for cooperation among the sectoral operators and absence of transparent governance structures.

A collaborative effort is necessary at the national, regional and international levels among all stakeholders to overcome these challenges. Starting with the national level, a national broadband mission encompassing all sectors, regulators, public and private sector participants can join hands and chart an action plan. Governments and regulatory authorities can facilitate a conducive environment for the expansion of broadband by bringing in policies supporting infrastructure sharing. In Brazil, for instance, the three national regulatory agencies for telecommunication, electricity and oil came together in 1999 to adopt a common regulatory framework for the sharing of infrastructure covering critical issues like rights of way on private property.[45] The new regulatory focus should be collaboration between the sectors and their regulators, as we can no longer act in silos.[46]

[45] Tracy Cohen and Russell Southwood, "Extending Open Access to National Fibre Backbones in Developing Countries", a discussion paper for ITU's Eighth Global Symposium for Regulators, 2008. Available at https://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR08/discussion_papers/Cohen_Southwood_web.pdf.

[46] ITU, *Global ICT Regulatory Outlook 2020* (Geneva, 2020). Available at https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-BB.REG_OUT01-2020-PDF-E.pdf.

2.4 Economics of Shared Infrastructure: CapEx and OpEx

Many issues need to be considered before planning any infrastructure sharing among different sectors. If these issues are considered, factored in, and in case of conflicts, resolved amicably, the prospect of a win-win partnership emerges. Considering the basic aspects of partnership, a broad discussion on the overall advantages and potential challenges of cross-sectoral infrastructure sharing is necessary before getting into a more detailed examination of cost-effectiveness and market competition[47] issues in the next section.

The most prominent advantage of infrastructure sharing is decreased **CapEx**[48] and **OpEx**.[49] Any infrastructure building is expensive, and the need for capital expenses upfront deters many from entering a market, especially if the potential revenue is limited (e.g., in a rural community). The CapEx factor becomes more critical as the market becomes more competitive. An operator may find it hard to survive in the competition to recover a huge initial investment. In such a circumstance, it goes without saying that if operators of different sectors join hands and share their infrastructures, they will gain by reducing CapEx. While the infrastructure owner can generate additional revenue and recover its initial investment faster, the partner can also save its CapEx requirement (by not having to build those infrastructures) and enter a market with a more competitive advantage. Partners can pass on these savings to innovate in operations and service delivery.

Building new infrastructure not only costs money, it also costs time and delays the launching of a new operator or service. Studies suggest that by sharing infrastructures, a network operator can save up to 40 per cent of the CapEx,[50] and in the emerging 5G context this savings can be more than 40 per cent just by sharing the antenna site.[51] Hence, partners from diverse sectors – roads, railways, power, water and telecommunication – can benefit from infrastructure sharing. According to an estimate in Thailand, 70 per cent of broadband infrastructure's cost is ascribed to civil construction, right-of-way expenditure and site acquisition. An alternative is the aerial

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[47] Competition is the rivalry between companies selling similar products and services with the goal of achieving revenue, profit and market share growth. Market competition motivates companies to increase sales volume by utilizing the four components of the marketing mix, also referred to as the four P's - product, price, place and promotion. Source: James Carnite, "What is Competition in Marketing? - Definition & Types", *Study.com*. Available at https://study.com/academy/lesson/what-is-competition-in-marketing-definition-types-quiz.html.

[48] CapEx refers to funds that are used by a company for the purchase, improvement or maintenance of long-term assets to improve the efficiency or capacity of the company. Long-term assets are usually physical, fixed and non-consumable assets such as property, equipment or infrastructure, and have a useful life of more than one accounting period. Source: Corporate Finance Institute, "What are Capital Expenditures?" Available at https://corporatefinanceinstitute.com/resources/knowledge/accounting/capital-expenditures/.

[49] OpEx is an expense a business incurs through its normal business operations, such as rent, equipment, inventory costs, marketing, payroll, insurance, step costs, and funds allocated for research and development. Source: Investopedia, "Operating Expense", 2 September 2021. Available at https://www.investopedia.com/terms/o/operating_expense.asp#:~:text=An%20operating%20expense%20is%20an,allocated%20for%20research%20and%20development.

[50] Booz & Company, "Sharing Mobile Networks: Why the Pros Outweigh the Cons", 2012.

[51] Ferry Grijpink and others, "Network sharing and 5G: A turning point for lone riders", *McKinsey & Company*, 23 February 2018. Available at https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/network-sharing-and-5g-a-turning-point-for-lone-riders.

fibre-optic cables installed on electricity poles (Case Study 3), which is estimated to have saved 80 per cent of construction costs and 40 per cent of project time.[52] In Telangana state in India, optical fibre is being laid alongside the drinking water pipeline to expand affordable and high-speed broadband connectivity.[53]

Case Study 3: Microduct in Thailand

The Metropolitan Electricity Authority of Thailand announced the success of its pilot deployment of the new technology – microduct – a single pipe installed on a power pole to group tangled cables together. The single overhead communication cable technique has been used by applying the aerial microduct for underground cables for installation on power poles, and using the air blown system to push cables into a pipe. The microduct has high tensile strength made of fibre-reinforced plastic – the 3.5cm diameter can accommodate up to 672 core fibre-optic cables. The Metropolitan Electricity Authority, in coordination with telecom operators and relevant agencies have worked together to deploy the microduct technology to help build a stable power system and beautify the city.

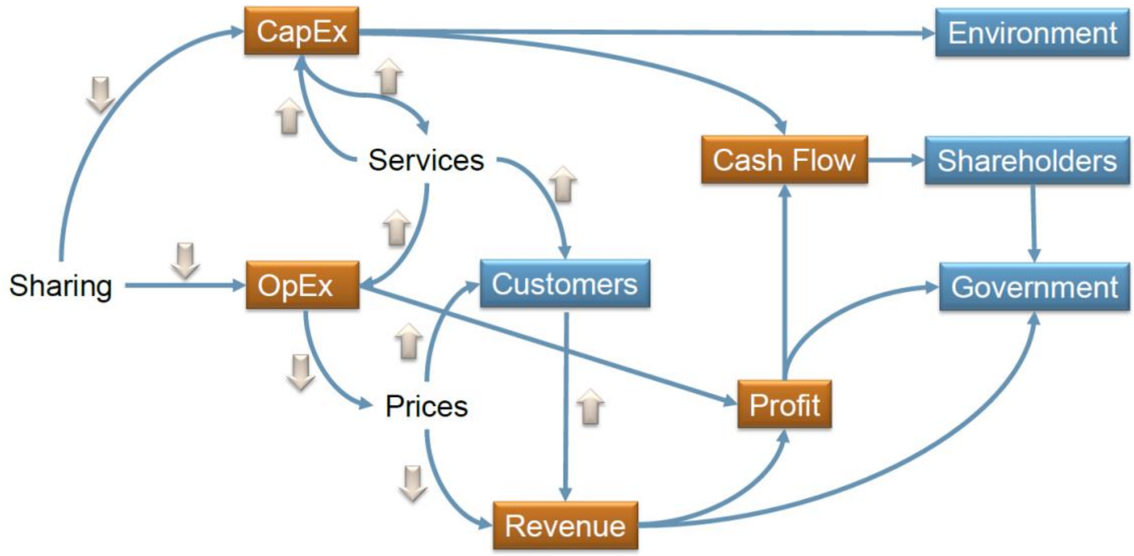
Source: Metropolitan Electricity Authority of Thailand, “MEA succeeds in solving cable mess by using Microduct technology for the first time in Thailand”, 5 October 2018. Available at https://www.mea.or.th/en/content/detail/87/4046.

In terms of savings in OpEx, infrastructure sharing can benefit the sectoral operators in reducing maintenance costs, power consumption, rents for sites and buildings, and security expenses. OpEx can be reduced by almost half through infrastructure sharing.[54] A study showed OpEx savings of three per cent for power, mast, air conditioning, generator for uninterrupted power supply and site rentals with infrastructure sharing, and in a congested locality, OpEx savings range from 5 to 20

[52] Khine Kyaw, “Call for broadband infrastructure sharing”, *The Nation,* 19 September 2018. Available at https://www.nationthailand.com/business/30354832.
[53] Tele.net, "State Initiatives", August 2019. Available at https://tele.net.in/1139-2.
[54] Ferry Grijpink and others, “Network sharing and 5G: A turning point for lone riders”, *McKinsey & Company*, 23 February 2018. Available at https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/network-sharing-and-5g-a-turning-point-for-lone-riders.

per cent.[55] Savings can also be accrued from a combination of other OpEx such as field services, network operation centre costs, spare parts management and ongoing network optimization.[56] Infrastructure sharing offers four major OpEx benefits – site costs, maintenance, power and backhaul.[57]

Figure 6: Direct and indirect benefits from infrastructure sharing



Source: Communications Regulators' Association of Southern Africa and ITU, "ICT and Broadcasting Infrastructure Sharing Guidelines", 21 February 2016. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/CRASA-ITU-IS_Guidelines_Final_Jan2018.pdf.

Besides CapEx and OpEx savings, infrastructure sharing brings in many other direct and indirect benefits for all – owners, operators, service providers and the end users (Figure 6). Customers usually benefit from the operators reinvesting the savings in new/enhanced services, further/faster geographic service roll-out, improved service quality or lower prices. In turn, the government benefits from increased tax revenues resulting from increases in value-added (sales) tax (from higher revenue), corporation tax (from higher profits) and personal income tax (from higher employment, investment, etc.). Numerous studies have shown that increased broadband penetration and consumption increases national productivity and investment which in turn is reflected in gross domestic product, employment and further tax revenue. Finally, there are usually environmental benefits such as reduced carbon footprint due

[55] T. Frisanco and others, "Infrastructure sharing and shared operations for mobile network operators: From a deployment and operations view", paper presented at 2008 IEEE Network Operations and Management Symposium, May 2008, pp. 129-136.
[56] Djamal-Eddine Meddour, Tinku Rasheed and Yvon Gourhant, "On the Role of Infrastructure Sharing for Mobile Network Operators in Emerging Markets", *Computer Networks,* vol. 55, no. 7 (2011), pp. 1576-1591.
[57] Dongwook Kim, Sungbum Kim and Hangjung Zo, "Analyzing the economic effects of past mobile network sharing deals for future network deployment", *Electronics and Telecommunications Research Institute Journal*, vol. 40, no. 3 (2018), pp. 355-365.

to energy savings, reduced travel by field engineers, reduced road traffic disruption and less visual pollution in the case of radiocommunication towers.[58]

2.5 Issues of Market Distortion

The advantages of cross-sectoral infrastructure sharing have been discussed. However, there are challenges and risks that may arise. One of the challenges is price regulation. Generally, regulation is a measure to prevent market failures, ensure the quality of services and products, and safeguard consumers' interests and larger social good in access to ICT services.[59] But, when multiple sectors are involved in infrastructure sharing, price regulation can distort the market and lead to cross-subsidization of one sector at the cost of the other, and it may ultimately discourage infrastructure sharing.[60]

Closely associated with the issue of regulation is competition. Two types of competition are relevant here: (1) **service-based competition**, where a new operator uses the existing infrastructure of an incumbent at a regulated price; and (2) **infrastructure- or facility-based competition**, where the new entrant builds new infrastructures or facilities and then competes with the incumbent in terms of services, quality and coverage.[61]

In the initial stages of entry, service-based competition helps price competition and seems beneficial for society. In the long run, facility-based competition prompts investment in infrastructures and thus serves the expansion of services.[62] Several studies have found that forcing an incumbent to share its infrastructures at a regulated price discourages a new entrant's move towards facility-based competition or adoption of innovative technologies, and is detrimental to the infrastructure sharing approach. On the contrary, some researchers find that service-based competition promotes lower prices in service delivery, offering affordable prices for the end user.[63] The final impact of competition in the market depends on the entrant's "make or buy" decision (Box 2).

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[58] Communications Regulators' Association of Southern Africa and ITU, "ICT and Broadcasting Infrastructure Sharing Guidelines", 21 February 2016. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/CRASA-ITU-IS_Guidelines_Final_Jan2018.pdf.
[59] Vikas Kathuria, "Conflict between Regulation and Competition Law in the Indian Telecom Sector", *Economic and Political Weekly*, vol. 53, no. 38 (2018), pp. 38-44.
[60] World Bank, "Cross-Sector Infrastructure Sharing Toolkit". Available at https://ddtoolkits.worldbankgroup.org/infra-sharing.
[61] Jose Marino Garcia and Tim Kelly, "The economics and policy implications of infrastructure sharing and mutualisation in Africa", Background Paper for the World Development Report, World Bank, November 2015. Available at https://thedocs.worldbank.org/en/doc/533261452529900341-0050022016/original/WDR16BPInfrastructureMutualisationGarcia.pdf.
[62] Wolfgang Briglauer, Klaus Gugler and Adhurim Haxhimusa, "Facility- and Service-based Competition and Investment in Fixed Broadband Networks: Lessons from a Decade of Access Regulations in the European Union Member States", *Telecommunications Policy*, vol. 40, no. 8 (2016), pp. 729-742.
[63] Doug Brake and Robert D. Atkinson, "A Policymaker's Guide to Broadband Competition", *Information Technology and Innovation Foundation*, 3 September 2019. Available at https://itif.org/publications/2019/09/03/policymakers-guide-broadband-competition.

Box 2: Three regulatory alternatives

- **Fully distributed costs regulation**: Under this regime the incumbent may recoup NGN investment costs through the access price, regardless of the NGN's market success. The entrant is forced to cover part of the investment costs, thereby reducing the potential downside for the incumbent.
- **Risk-sharing**: Telecom operators jointly (cooperatively) deploy and share the costs of NGN. Each operator may use the NGN for a new NGN customer without any further access payment.
- **Regulatory holiday**: The incumbent is not forced to give access to its NGN and it can set the access price without regulatory oversight (at least for a certain period). The access price is subject to Nash bargaining between the incumbent and the entrant.

Source: Extracted from R. Nitsche and L. Wiethaus, “Access regulation and investment in next generation networks – A ranking of regulatory regimes”, *International Journal of Industrial Organization*, vol. 29, no. 2 (2011), pp. 263-272.

In the case of cross-sectoral infrastructure sharing, it becomes more complex as multiple sectoral regulators may be involved. One of the major issues arises when the additional revenue generated from infrastructure sharing is offset against a utility’s revenue requirement. It was pointed out earlier that the additional revenue generated from infrastructure sharing will help a sectoral player expand its coverage, improve services and boost growth. However, in a rate-regulated utility, the tariff rate is based on its potential revenue collection, operational costs and a time-bound return on its investment. In this scenario, if the utility’s tariff (revenue) is reduced because it has earned some extra revenue from infrastructure sharing, then there is no incentive for that utility to pursue infrastructure sharing. In other words, if the additional revenue from infrastructure sharing goes indirectly to benefit end users of another sector, why would a utility take up the additional burden of infrastructure sharing and its associated additional work.[64] The concern is with the national regulatory authorities mandating infrastructure sharing and imposing an *ex-ante* price regulation[65] even where market domination by an incumbent is not ascertained.

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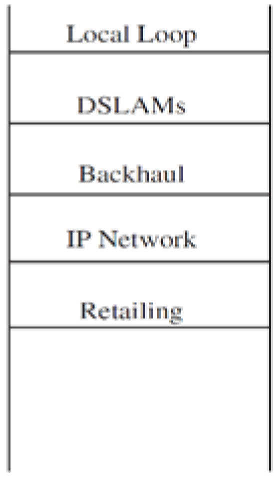
[64] Jonathan Woetzel and others, "Bridging Infrastructure Gaps: Has the World Made Progress?" *McKinsey & Company*, October 2017. Available at https://www.mckinsey.com/business-functions/operations/our-insights/bridging-infrastructure-gaps-has-the-world-made-progress.

[65] *Ex ante* means before any event happens. In this case, it is a price regulation fixed before the actual competition plays out or market scenarios are clear. *Ex post* is based on actual results rather than forecasts.

Box 3: Ladder of investment



Ladder of replicability for broadband

The ladder of investment is a regulatory approach proposed by Martin Cave in 2006, which has been widely embraced by national regulatory authorities in the European telecom sector. The approach entails providing entrants, successively, with different levels of access – the "rungs" of the investment ladder, while inducing them to climb the ladder by setting an access charge that increases over time or by withdrawing access obligations after some pre-determined date (i.e., by setting sunset clauses). Proponents of the ladder of investment approach claim that these regulatory measures ensure service-based entry and facility-based entry are complements in promoting competition.

Regulators have shown a strong interest in this approach. By adopting this approach, a regulator reconciles the trade-off between promoting two forms of competition, and hence, short-term gains from service-based competition can be realized without impeding facility-based entry in the longer term. It is important to note that the ladder of investment approach does not presume that service-based competition is a steppingstone to facility-based entry. Rather, it describes how this could be achieved with regulation. Neither does it claim that the approach is a way to achieve facility-based competition.

Source: Extracted from Marc Bourreau, Pinar Doğan and Matthieu Manant, “A Critical Review of the "Ladder Investment" Approach”, *Telecommunications Policy*, vol. 34, no. 11 (2010), pp. 683-696.

Whether infrastructure is being shared within or across sector, the dichotomy remains – whether to force the incumbents to share their infrastructures and fix the price of access, or leave it to the partners to decide through mutual collaboration. The emerging trend is geared towards *ex-post* price regulations where the intending infrastructure sharing partners are left to mutually decide on the terms, and the regulators intervene only when any party hampers competition. The idea is to restrict *ex-ante* regulatory directives only in cases where an incumbent is seen as a strong monopoly player who can recourse to pose deterrents to new entrants.

Table 2: Changing paradigms of regulatory approach

	Historical perspective	Future perspective
Scope	Telecom-specific policies and regulations to ensure competition	Policies that recognize impact across entire ICT value chain
	Technology-specific market definitions	Converged fixed/mobile/cable definitions
Approach	Heavy regulatory approach	Lightened approach and non-regulatory tools (e.g. transparency, self-regulation)
	Primarily ex-ante intervention to avoid harm	More ex-post to encourage experimentation (where competitive)
	Regulations established by government authorities	Collaboration with industry and other organizations
Level of engagement	Policies and regulations established by national bodies and in select cases institutions (e.g. ITU)	Policies and regulations established at appropriate level (e.g. international where harmonization required, local where experimentation needed)

Source: World Economic Forum, *Delivering Digital Infrastructure: Advancing the Internet Economy* (Geneva, 2014). Available at http://www3.weforum.org/docs/WEF_TC_DeliveringDigitalInfrastructure_InternetEconomy_Report_2014.pdf.

Stakeholders of cross-sectoral infrastructure sharing realize that mandating sharing by regulators is not sufficient. The partnering sectors must also collaborate and adopt a mutually agreed upon business plan in which rate-regulated utilities are not de-incentivized for sharing their infrastructure.[66] There have been many paradigm shifts in regulatory approaches over the years (Table 2), and the multiplicity of sectors in delivering broadband services is a reality. ICT regulatory mechanisms need to be broadened, considering the realities, scopes and even limitations of different sectors that will share their infrastructures to expand broadband access. There are many scopes for governments to experiment with different models and approaches and support those that work in a given scenario. Light-handed regulations or targeted tax incentives can trigger the sectors to innovate and prosper. Regulators can, however, lay down the boundaries in terms of broad policy guidelines to show the areas where they would keep a watch (e.g., against anti-competition behaviours) and the spaces they would leave to the actors to play out in the market.[67]

This section concludes by referring to Frischmann who argues that infrastructures are "commons for the community, and we should be ready to share them in an open, non-

[66] Doug Brake and Robert D. Atkinson, "A Policymaker's Guide to Broadband Competition", *Information Technology and Innovation Foundation*, 3 September 2019. Available at https://itif.org/publications/2019/09/03/policymakers-guide-broadband-competition.
[67] World Economic Forum, *Delivering Digital Infrastructure: Advancing the Internet Economy* (Geneva, 2014). Available at http://www3.weforum.org/docs/WEF_TC_DeliveringDigitalInfrastructure_InternetEconomy_Report_2014.pdf.

discriminatory manner when it is feasible to do so".[68] This cannot be more true when we consider cross-sectoral infrastructure sharing to provide broadband access, as this is the new lifeline for all socioeconomic activities in the world. When infrastructures are essential to provide a minimum facility (broadband) to ensure productivity, development and growth in our society today, perhaps time is ripe to think of infrastructure sharing not only as resource distribution and revenue generation, but also as a public good to ensure continued access to our infrastructure commons.

[68] Brett M. Frischmann, *Infrastructure – The Social Value of Shared Resources* (Oxford and New York, Oxford University Press, 2012).

2.6 Summary

The major advantages of cross-sectoral infrastructure sharing, especially to expand broadband access, are manifold, as follows:

- Shared cost of deployment will lead to expansion of the networks and improvement in quality.
- Reduced cost of operation will make the services cheaper for the user.
- More competition will provide more choices and better prices to the users.
- Third-party operators will gain entry into the market.

In a networked world that is heavily dependent on broadband connectivity, cross-sectoral infrastructure sharing should be well planned and supported by a long-term vision of the emerging nature of the digitalized world. An integrated approach is needed to encompass the five dimensions of infrastructure sharing in terms of technology, geography, architecture, partnerships and sharing arrangements. Strong collaboration is needed, and strategic ICT policies and plans must be developed to enable infrastructure sharing. Governments and national regulators need to step in where an incumbent poses challenges to sharing.

The most prominent advantage of infrastructure sharing is decreased CapEx and OpEx. However, one of the major challenges that may arise lies in price regulation, especially when multiple sectors and regulators are involved. Closely associated with the issue of regulation is competition. There are two types of competition – service-based competition and facility-based competition. The concern is with the national regulatory authorities mandating infrastructure sharing and imposing an *ex-ante* price regulation even where market domination by an incumbent is not ascertained.

ICT regulatory mechanisms need to be broadened, considering the realities, scopes and even limitations of different sectors that will share their infrastructures to expand broadband access. When infrastructures are essential to provide a minimum facility (broadband) to ensure productivity, development and growth in our society today, perhaps time is ripe to think of infrastructure sharing not only as resource distribution and revenue generation, but also as a public good to ensure continued access to our infrastructure commons.

2.7 Exercise: Check Your Progress

Answer the following:

1. Governments, industry and telecom companies are all looking for new ways to ________________ costs of deploying infrastructures.
2. Cross-sectoral infrastructure sharing can reduce _____________ of infrastructures.
3. Any potential collaboration between telecom operators and other sectors needs an _______________ approach.
4. Reduced cost of operation will make the services _________ for the user.
5. In service-based competition, a new operator uses the existing infrastructure of an ______________.
6. Concomitant deployment of ducts and/or fibre-optic cables during the construction of infrastructure such as new roads, highways, railways and power transmission lines is called _________________.
7. A partnership model where a common facility is operated by all partners involved is called _______________.
8. The five dimensions of infrastructure sharing are technology, geography, architecture, partners and __________________.
9. Modern designs of roads, power lines, gas, water and sewerage installations can keep provisions for ___________ that telecom operators can use.
10. Sectoral infrastructure owners need better _________________ facilities for their own operational purposes.
11. The most prominent advantage of infrastructure sharing is the decreased capital expenditure and _________________ expenditure.
12. Savings from installations and revenues from infrastructures can attract ____________ to build common infrastructures.
13. Facility-based competition is also known as ____________-based competition.
14. The final impact of competition in the market is dependent on the entrant's make or _______________ decision.
15. Frischmann argues that infrastructures are ____________ resources for the community.

2.8 Suggested Readings and Online Resources

1. Deloitte and Association for Progressive Communications (2015). Unlocking Broadband for All: Broadband Infrastructure Sharing Policies and Strategies in Emerging Markets. Available at https://www.apc.org/en/pubs/unlocking-broadband-all-broadband-infrastructure-s.
2. Garcia, Jose Marino, and Tim Kelly (2015). The economics and policy implications of infrastructure sharing and mutualisation in Africa. Background Paper for the World Development Report, World Bank, November 2015. Available at https://thedocs.worldbank.org/en/doc/533261452529900341-0050022016/original/WDR16BPInfrastructureMutualisationGarcia.pdf.
3. ITU (2020). *Global ICT Regulatory Outlook 2020*. Geneva. Available at https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-BB.REG_OUT01-2020-PDF-E.pdf.
4. ITU and UNESCO (2020). *The State of Broadband 2020: Tackling digital inequalities - A decade of action*. Geneva. Available at https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.21-2020-PDF-E.pdf.
5. World Economic Forum (2014). *Delivering Digital Infrastructure: Advancing the Internet Economy*. Geneva. Available at http://www3.weforum.org/docs/WEF_TC_DeliveringDigitalInfrastructure_InternetEconomy_Report_2014.pdf.

3. POLICY AND REGULATORY ISSUES

3.1 Introduction

According to Webster's New World Telecom Dictionary, regulation originates from the Latin word "*regula*" that means rule, and regulation means "rule or order established by governmental bodies and having the force of law".[69] In most countries, there are sectoral regulators. In telecommunication, there is sometimes more than one regulatory agency that controls the operations of the sector. But most countries are guided by a narrow vision of regulation,[70] which is primarily concerned with the financial aspects and the market environment – ensuring competition among the players, preventing monopolies and guarding consumers or end users against exploitation by dominant players.

In cases of regulators mandating infrastructure sharing, economic viability is a major concern in expanding services in remote areas with a limited number of potential consumers. However, besides considering the economic aspects, the social aspects of regulation are also important.[71] There is an emerging concept of "social regulation" that focuses on social welfare and greater public interest.[72] Here, the regulator is not hinged upon providing remedies for market failures but looks for social justification of the regulations. This social vision underlines that:[73]

> *Regulation is the sustained and focused attempt to alter the behaviour of others according to defined standards or purposes with the intention of producing a broadly identified outcome or outcomes, which may involve mechanisms of standard-setting, information-gathering and behaviour-modification.*

This section discusses policy and regulatory approaches to tackling market distortions and the unfair competition that incumbents raise. The section begins by describing the emerging approaches to regulations from different perspectives – technical, economic and social. Next, cross-sectoral infrastructure sharing as voluntary or mandatory processes and the evolving market dynamics around these different arrangements are discussed. This includes examining the role of regulators mandating infrastructure sharing in the context of commercially non-lucrative rural broadband deployment programmes and ring-fenced funding arrangements like universal service funds. The section ends with a discussion on different policy issues related to cross-sectoral infrastructure sharing that can support and facilitate the faster roll out of broadband connectivity. Some illustrative cases are presented to support the policy arguments.

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[69] Ray Horak, *Webster's New World Telecom Dictionary* (Indianapolis, Wiley Publishing, 2008).
[70] Tony Prosser, *The Regulatory Enterprise: Government, Regulation, and Legitimacy* (New York, Oxford University Press, 2010).
[71] Anthony Ogus, *Regulation: Legal Form and Economic Theory* (Oxford, Clarendon Press, 1994).
[72] Olga Batura, *Universal Service in WTO and EU Law: Liberalisation and Social Regulation in Telecommunications* (The Hague, Asser Press and Springer, 2016).
[73] Jacint Jordana and David Levi-Faur, *The Politics of Regulation in the Age of Governance* (Cheltenham, Edward Elgar Publishing, 2004).

3.2 Learning Objectives

At the end of this section, you will be able to:

- Understand the different aspects of regulations.
- Identify the different approaches to regulations in the telecommunication sector.
- Differentiate between the mandatory and voluntary nature of regulations.
- Explain the policy issues related to cross-sectoral infrastructure sharing.

3.3 Legal and Regulatory Issues in the Telecommunication Sector

A broad understanding of regulatory agencies' economic and social intents emerges from academia and industry. Baldwin and others identified three major aspects of regulations – targeted rules, government economic interventions and social controls.[74] Majone argued that a regulatory state is emerging as states intervene to facilitate the entry of new players in sectors like telecommunication by restraining the powerful incumbent monopolies through a process of deregulation and re-regulation.[75] In most cases, initial deregulation or privatization meant price regulation and any social regulation (e.g., health safety). What has emerged is not a complete obliteration of regulations, but a new kind of regulation that is more flexible and open to the idea of a participatory approach in governing the utilities. This re-regulation is commonly termed as regulatory reform in the literature that combines deregulation and regulation.[76]

Telecom policies and regulations occupy an interesting area among academia, industry and users. The liberalization of the economies and a parallel advancement in technologies brought the privatization movement in which the earlier monopolies, mainly government entities, were dismantled. These entities tried to hold their grounds by citing the service they provide to the marginalized and the poor living in remote communities at an affordable cost. These incumbents argued that private players would only be interested in providing services in lucrative urban areas and would avoid remote areas. In response, the concept of universal service fund was put forward in the 1990s and regulations around universal service were seen as a socially-oriented policy instrument.[77]

Regulations are often seen as government interventions justifiable only in special circumstances like a market failure. However, with the emergence of new technologies and the convergence of technologies, utilities and services necessary to run a modern economy, it becomes increasingly clear that ICT is a universal service to be provided to all citizens. Telecom regulations, therefore, need to focus on providing ICT connectivity as a minimum utility for all. Theoretical frameworks of social embeddedness of markets categorize telecom facilities as social services requiring special regulations.[78] As argued by Karl Polanyi, the concept of social embeddedness of markets provides a solid ground and justification for the government to interfere (regulate) considering a larger social good. Regulation is a necessity to the growth of the market itself (Box 4).

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[74] Robert Baldwin, Colin Scott and Christopher Hood, eds., *A Reader on Regulation* (Oxford, Oxford University Press, 1998).
[75] Giandomenico Majone, *Regulating Europe* (London, Routledge, 1996).
[76] Ibid.
[77] Olga Batura, *Universal Service in WTO and EU Law: Liberalisation and Social Regulation in Telecommunications* (The Hague, Asser Press and Springer, 2016).
[78] Karl Polanyi, *The Great Transformation: The Political and Economic Origins of our Time*, second edition (Boston, Beacon Press, 2001).

Box 4: Polanyian theory of social embeddedness of markets

In analysing the development of economic systems through history, Polanyi concluded that economic activity is just one of many functions of the social order and is therefore subject to a non-economic rationale. The market as a part of the economic system had been embedded in the society, until the development of the market economy in the nineteenth century reversed relations between economy and society: society became subordinated to market requirements and market logic. Polanyi considered this dis-embedding move as not a natural development of the economy, but a deliberate political choice of the state, realized with the help of legal instruments.

This dis-embedding move can be understood as an institutional separation of the market from social relations. Instead of social institutions such as family and kinship, the market relies on the driving force of prices that follow the interplay of supply and demand. Through these intrinsic mechanisms, the market regulates itself independently from society, but is able to affect the latter considerably because market components derive from society. In the words of Polanyi: "The social history of our time is the result of a double movement: The one is the principle of economic liberalism, aiming at the establishment of a self-regulating market; the other is the principle of social protection aiming at the conservation of man and nature as well as productive organization".

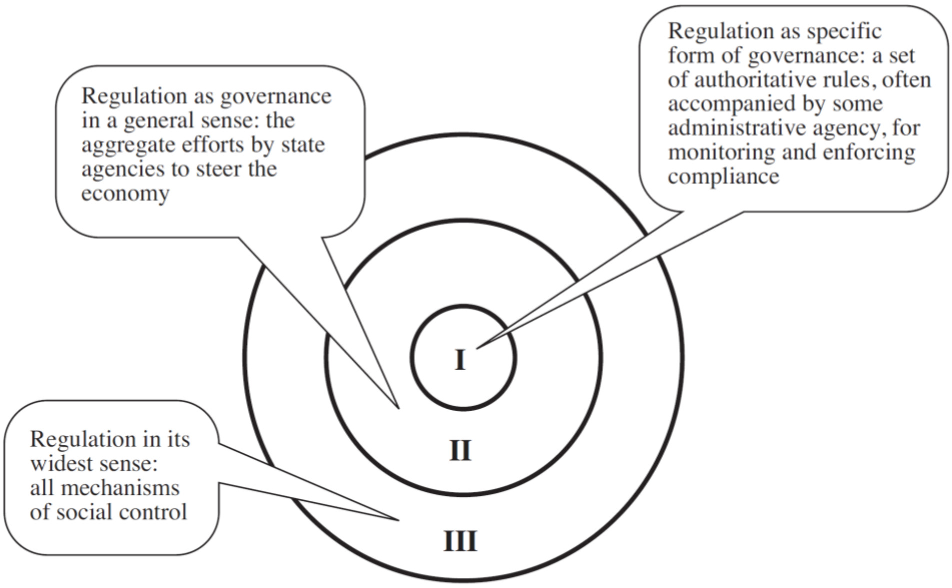
Source: Extracted from Olga Batura, *Universal Service in WTO and EU Law: Liberalisation and Social Regulation in Telecommunications* (The Hague, Asser Press and Springer, 2016).

Three Aspects of Regulation

Some scholars have described regulation as having three main aspects, beginning with a narrow inner circle and expanding gradually to include broader circles or issues.[79] The first aspect occupying the narrowest inner circle is rules, regulations, guidelines, statutes and laws promulgated through agencies and usually supervised by a regulator for compliance. These are specific sectoral regulations used as a governance instrument to regulate an otherwise free and open market. Engulfing this inner circle is a larger circle indicating the second aspect of regulation as a general framework for steering the overall economy. It is an overarching national goal or vision that drives regulatory concerns and this aspect covers governance as a national agenda. The third aspect of regulation is the broadest and covers all types of social control mechanisms the state exerts. It encompasses the larger, global or universal issues such as those related to climate change or the information society that drive regulatory measures. These three aspects are represented graphically in a set of three concentric circles (Figure 7). In the early 1980s, regulation meant a government tool or instrument of control over economic activities (Circle II). After the 1990s, this has shifted towards more narrowed sector-specific regulations in the wake of regulatory reforms worldwide and the emergence of independent regulatory agencies.[80]

[79] For details see: Robert Baldwin, Colin Scott and Christopher Hood, eds., *A Reader on Regulation* (Oxford, Oxford University Press, 1998); and Jacint Jordana and David Levi-Faur, *The Politics of Regulation in the Age of Governance* (Cheltenham, Edward Elgar Publishing, 2004).
[80] Jacint Jordana and David Levi-Faur, *The Politics of Regulation in the Age of Governance* (Cheltenham, Edward Elgar Publishing, 2004).

Figure 7: Three aspects of regulation



Source: Jacint Jordana and David Levi-Faur, *The Politics of Regulation in the Age of Governance* (Cheltenham, Edward Elgar Publishing, 2004).

Scholars like Prosser,[81] Brownsword,[82] and Baldwin and others[83] argue that regulation is justified not primarily as a response to market failures but to protect human rights and social solidarity. Prosser further elaborates on the four major justifications favouring regulations: (1) economic efficiency and consumer choices; (2) protection of rights; (3) social solidarity; and (4) mechanisms for dispute resolution. Therefore, regulations are imposed based on several considerations – citizenship, equity, justice and non-discrimination or other social policies (Table 3). Over the years, theoretical discussions on the need for regulations and the substantial experiences gained by the regulatory community have further consolidated a set of models and policies. In any sector or industry, regulations may be justified with more than one rationale, and it may seek to address more than one economic, political or social issue.

It is important to note that regulations may fail to yield expected results, and there may still be an issue like market failures.[84] All regulatory mechanisms have their strengths and weaknesses in policy directions, economic agendas, enforcement mechanisms and structures. Therefore, before selecting or rejecting any regulatory framework in any country, careful consideration of all pros and cons of both the market and the regulation is necessary to arrive at an informed decision.

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[81] Tony Prosser, "Regulation and Social Solidarity", *Journal of Law and Society*, vol. 33, no. 3 (2006), pp. 364-87.
[82] Roger Brownsword, ed., *Global Governance and the Quest for Justice – Vol. IV: Human Rights* (Oxford, Hart Publishing, 2004).
[83] Robert Baldwin, Martin Cave and Martin Lodge, *Understanding Regulation: Theory, Strategy, and Practice*, second edition (New York, Oxford University Press, 2012).
[84] Ibid.

Table 3: Rationale for regulations

Rationale	Main aims of regulation	Example
Monopolies and natural monpolies	Counter tendency to raise prices and lower output. Harness benefits of scale economies. Identify areas that are genuinely monopolistic.	Utilities.
Windfall profits	Transfer benefits of windfalls from firms to consumers or taxpayers.	Firm discovers unusually cheap source of supply.
Externalities	Compel producer or consumer to bear full costs of production, rather than pass on to third parties or society.	Pollution of river by factory.
Information inadequacies	Inform consumers to allow market to operate.	Pharmaceuticals. Food and drinks labelling.
Continuity and availability of service	Ensure socially desired (or protect minimal) level of 'essential' service.	Transport service to remote region.
Anti-competitive and predatory pricing behaviour	Prevent anti-competitive behaviour.	Below-cost pricing in transport.
Public goods and moral hazard	Share costs where benefits of activity are shared but free-rider problems exist.	Defence and security services. Health Services.
Unequal bargaining power	Protect vulnerable interests where market fails to do so.	Health and Safety at Work.
Scarcity and rationing	Public interest allocation of scarce commodities.	Petrol shortage.
Rationalization and coordination	Secure efficient production where transaction costs prevent market from obtaining network gains or efficiencies of scale. Standardization.	Disparate production in agriculture and fisheries.
Planning	Protect interests of future generations. Coordinate altruistic intentions.	Environment.
Human rights	Protection of weaker citizens.	Discrimination. Embryology.
Social protection	Social solidarity.	Broadcasting.

Source: Robert Baldwin, Martin Cave and Martin Lodge, *Understanding Regulation: Theory, Strategy, and Practice*, second edition (New York, Oxford University Press, 2012).

Many see regulations as prohibitive or opposite to the idea of a free market. However, this may be a very simplistic perspective. Regulations are sometimes seen as the second-best choice if the free-market principles, such as economic freedom and consumer choices, fail to deliver.[85] Regulations can also be seen to provide confidence and transparency to market operations.[86]

Regulatory Approaches in the Telecommunication Sector

Prosser identified two major visions of regulations. One is government intervention as a measure of sheer economic efficiency. Regulators respect the private sector's autonomy, self-regulation and mutual contractual arrangements among the players.

[85] Tony Prosser, *The Regulatory Enterprise: Government, Regulation, and Legitimacy* (New York, Oxford University Press, 2010).
[86] Tony Prosser, *Law and the Regulators* (Oxford, Clarendon Press, 1997).

The other vision considers regulation as a joint enterprise where economic and social or distributive justice factors are considered. Based on their rationale for existence, four models of regulations are enlisted, as follows:[87]

1. Economic efficiency and consumer choice (e.g., infrastructure sharing)
2. Protection of rights (e.g., right to data privacy)
3. Social solidarity (e.g., broadband for all)
4. Deliberation (e.g., mediating between operators to resolve issues)

While discussing telecom regulations, it is important to keep in mind the theoretical basis and assumptions that go with the concept of regulation, policy and legal frameworks. Telecom infrastructure regulations (network, equipment and services) can broadly be divided into economic or coopetition-related issues[88] and non-economic or public policy-related matters.[89] The economic aspects of regulations focus on sustaining a competitive market at the national, regional and global levels. The non-economic aspects of regulations cover the primary concerns of providing affordable quality ICT services to all and encompass issues like the environment, health, safety, privacy and neutrality.

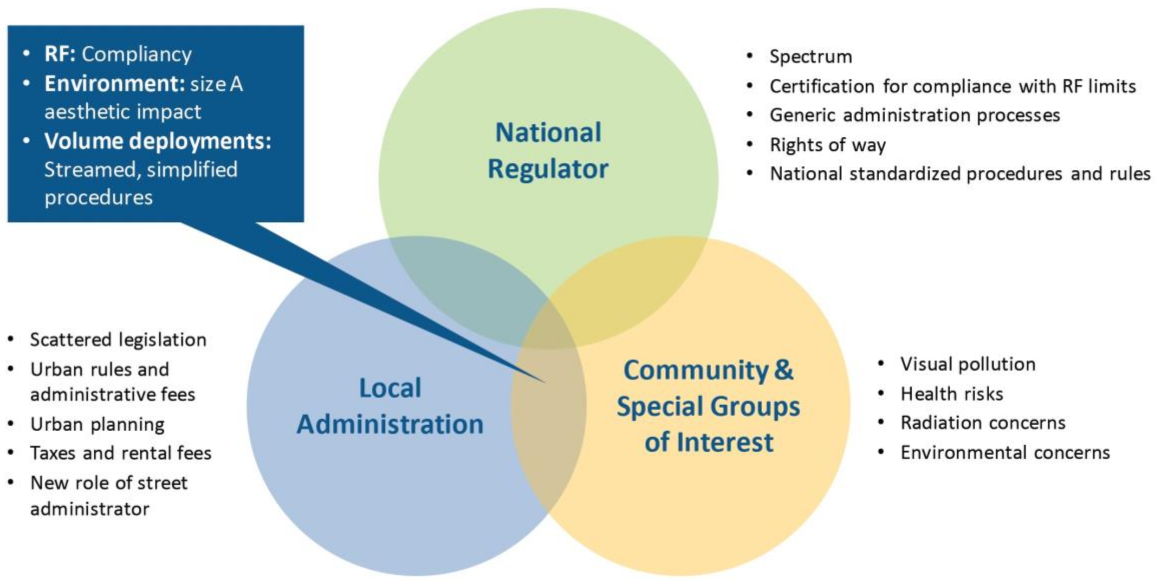
Two aspects of the evolution of telecom regulations across the world may be noted here. First, the boundaries of regulations concerning infrastructure and content are now diminished with technological advancement. Content issues are often intermingled with network-related aspects. Second, to leapfrog in ICT development, especially in developing countries, the telecom sector opened for competitive participation before the relevant regulatory frameworks could be put in place. In India, for instance, mobile services opened for competition in 1992 but without a corresponding change in regulatory mechanism. Later, a telecom policy was established in 1994 that undermined private participation. Ultimately, it was in 1997 that the Telecom Regulatory Authority of India Act was adopted.[90] These two issues – technological advancement and compatibility of regulatory frameworks – continue to dominate debates around telecom regulations.

[87] Tony Prosser, *The Regulatory Enterprise: Government, Regulation, and Legitimacy* (New York, Oxford University Press, 2010).
[88] Coopetition is the act of both competition and cooperation among businesses. For more details, see Section 5.5.
[89] Ian Walden, ed., *Telecommunications Law and Regulation*, fifth edition (Oxford University Press, 2018).
[90] Rajni Gupta, "Telecommunications Liberalisation: Critical Role of Legal and Regulatory Regime", *Economic and Political Weekly*, vol. 37, no. 17 (2002), pp. 1668-75.

3.4 Voluntary vs Mandatory Regulations

The need to expand infrastructure, improve quality of service, promote innovation and accelerate technological advancements led to the liberalization of the telecom sector for open market competition. Simultaneously, stakeholders raised non-economic concerns such as universal access to ICT for all, individual privacy and consumer rights. Regulations are meant to address these issues that are often termed as public interests. Telecom services are both utilities and essential services like water, electricity and gas. For instance, the spectrum allotted to private companies are resources of the state, and hence it should be used for the welfare of all. Considering public interest, mandatory regulations are promulgated by governments on issues such as service quality and security-related information sharing. However, more specific issues between the stakeholders or sectoral players are often decided between parties involved through voluntary agreements and cooperation.

Figure 8: Regulatory focus at different levels



Source: Sousa and Heinrich, "Infrastructure Regulation: Overview and Impact on Towercos – The Delta Perspective", 2019.

The phenomenal growth in ICTs, number of consumers and geographical coverage of ICT networks have increased the complexity of regulating the sector at different levels (Figure 8). While the market has become fiercely competitive, with multiple players vying for customers, the cost of infrastructure deployment remains very high. As a result, the infrastructure builders need quite a long time to get their return on investment. Simultaneously, innovations can make their deployment obsolete much faster than initially planned. Under these circumstances, regulators need to balance their regulatory frameworks between mandatory and voluntary dimensions of regulations. This becomes more crucial as regulators can reduce entry barriers (like the cost of new infrastructure deployment), enabling new players to join the market to provide competition against the incumbents or dominant sectoral players.

As infrastructure sharing is one way to ease the entry of new players in the telecom sector, the regulatory concerns in such sharing attain much importance. The joint utilization of assets and services necessary to provide telecom service means the incumbent, which has built infrastructure over the years, should share its assets with a new entrant to market so that it can offer services in a competitive market. The Nepal Telecommunication Authority and Telecom Regulatory Authority of India mandates sharing of various telecom infrastructures, such as towers, sites, power and backbone.

The debate around regulations for infrastructure sharing is centred around whether it should be mandatory or better left as voluntary. Countries like Bangladesh, Bhutan and India have developed a series of consultation papers, guidelines and policy documents on this issue as there are no international standards or guidelines. Moreover, an increasing number of transnational initiatives like the Asia-Pacific Information Superhighway (AP-IS) are promoting cooperation and partnerships for addressing the digital divide and expanding connectivity among the nations.

The mandatory approach in telecom regulations considers telecommunication as an essential facility, and its access should therefore not be restricted, syndicated or monopolized in such a way as to obstruct the entry of a new player. This principle is highlighted in the *United States v. Terminal Railroad Association* (1912).[91] In this case, some railroad owners formed the association. No new railroad could become a member without their consent, thus effectively blocking any new operator from entering the city or using the railway bridge. The court found such association as illegal – restricting others' entry in the market by sharing an essential facility. The court further indicated that railroad operators must submit a plan with the provision for:[92]

> *The use of the terminal facilities by any other railroad not electing to become a joint owner, upon such just and reasonable terms and regulations as well, in respect of use, character, and cost of service, place every such company upon as nearly an equal plane as may be with respect to expenses and charges as that occupied by the proprietary companies.*

Similar to this principle, many telecom regulators mandate that operators or licence holders share at least passive infrastructures to reduce the cost of market entry, minimize duplication or cluttering of physical assets, and increase the coverage of ICT services in unserved and underserved areas. However, mandatory infrastructure sharing is not a universal formula for all. The market needs some level of maturity and size to adopt such a policy.[93] Some others argue that a mandatory approach will discourage investment in future infrastructures, and therefore, the right approach should be a regulatory framework that incentivizes a balanced mix of service-based and facility-based competitions.[94] An alternative "information facility" approach is sometimes adopted in which the regulator takes a technology-neutral stand to avoid

[91] US Supreme Court, "United States v. Terminal Railroad Ass'n, 224 U.S. 383 (1912)". Available at https://supreme.justia.com/cases/federal/us/224/383/.
[92] Ibid.
[93] Organisation for Economic Co-operation and Development, "OECD Global Forum on Competition: Competition Policy and Small Economies", 7 February 2003. Available at http://www.oecd.org/daf/competition/prosecutionandlawenforcement/2486724.pdf.
[94] Andrea Renda, "Competition–regulation interface in telecommunications: What's left of the essential facility doctrine", *Telecommunications Policy*, vol. 34 (2010), pp. 23–35.

mandatory unbundling and price control, create a level playing field for competition and provide respite to those who invest in new, high-speed technology.[95]

The other regulatory approach in telecommunication is voluntary sharing when it is left to the infrastructure owner's choice to adopt a sharing policy based on the costs and benefits. Operators' associations, groups or federations may support voluntary sharing regulations, whereas the government may offer state-owned infrastructure facilities for sharing and financial incentives like tax concessions. The Cellular Operators Association of India, for example, supported the 2008 guidelines issued by the Department of Telecommunications on infrastructure sharing. The operators welcomed the simplified regulatory processes, the scope for sharing active infrastructures and the government's universal service subsidy support.[96] Similarly, the Global System for Mobile Communications or GSMA in Bangladesh argues that government should adopt conducive regulatory guidelines for full-fledged active infrastructure sharing that should include sharing of radio access networks and core networks to reduce duplication of assets and investments, optimal use of the resources and cater to the increasing demand for connectivity because of the ongoing COVID-19 pandemic.[97]

It is recognized that the ideal competitive market in the telecom sector may not be achieved as the initial cost of infrastructure may deter new entrants from joining the competition. Many countries, especially in the European Union, tried to resolve this challenge by mandatory regulation like fixing the price for interconnection or compulsory facility sharing. However, competition in infrastructure remained a challenge and an elusive goal.[98] It is also realized that many governments and regulators tried unsuccessfully to compel incumbents to share their assets with new entrants. But, as Crawford noted: "Where incumbents act as gatekeepers, new technology will not emerge without regulatory help that creates a level playing field for competition and the free flow of information".[99]

Universal Access and Service

The concept of universal access and service deserves attention. With rapid changes in technology, the idea of universal access to a telephone or the Internet has undergone several changes, and today, broadband connectivity has become the bare minimum for all. Initially, universal services refer to those delivered at the individual or household level and universal access refers to a public facility to avail the services like a public phone or Internet centre. Over the years, both terms have merged to combine both access and service issues. With further convergence of technologies and public

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[95] Ibid.

[96] Cellular Operators Association of India, "Press Release: COAI warmly welcomes the DoT guidelines on infrastructure sharing", 1 April 2008. Available at https://cdn.coai.com/sites/default/files/2017-05/PRESS-RELEASE-Active-Infra-Sharing.pdf.

[97] GSMA, "Keeping Bangladesh connected: The role of the mobile industry during the COVID-19 pandemic", GSMA National Dialogues, 17 December 2020. Available at https://www.gsma.com/mobilefordevelopment/connected-society/gsma-national-dialogues/.

[98] Richard Hill, *The New International Telecommunication Regulations and the Internet: A Commentary and Legislative History* (Heidelberg, Springer, 2014).

[99] Susan Crawford, *Captive Audience: The Telecom Industry and Monopoly in the New Gilded Age* (New Haven, Yale University Press, 2013).

utility services in NGNs, ICT policymakers face new challenges in providing reliable and resilient universal broadband access and service to all.[100]

Table 4: Different aspects of universal access and universal service

ASPECT	UNIVERSAL ACCESS	UNIVERSAL SERVICE
Availability	*Focused coverage*	*Blanket coverage*
	Public access (e.g., at a payphone or telecentre)	*Private service on demand*
	Free emergency calls	*Free emergency calls*
Accessibility	*Walking distance, convenient locations and hours*	*Simple and speedy subscription*
	Inclusively designed premises (e.g., for wheelchair users); inclusively designed terminals or available assistance (e.g., for those with visual or hearing impairments)	Inclusively designed terminals and services (e.g., for those with visual or hearing impairments)
	Assistance from an attendant	Assistance through the terminal (e.g., by making calls or viewing help pages for the web)
	Adequate quality of service (e.g., having few failed call attempts)	Reasonable quality of service (e.g., having few dropped calls)
Affordability	Options of cash and card payment	The cost of average monthly usage is a small percentage of monthly gross national income per capita
	Options of cash and card payment	Options of cash, card and electronic payment
	Payment per use (e.g., for a single call or message or an hour of Internet access)	Flat rate, bundles of services or low monthly subscription fee

Note: Essential characteristics are in italics, while desirable characteristics are in regular font. Source: Colin Blackman and Lara Srivastava, eds., *Telecommunications Regulation Handbook* (Washington D.C. and Geneva, World Bank, InfoDev and ITU, 2011). Available at https://www.itu.int/pub/D-PREF-TRH.1-2011.

The goals of universal access and service are a major concern for the global efforts to promote conducive telecom policies and regulations while adhering to the necessities of open market competition.[101] Three key aspects of universal access and service are – availability, accessibility and affordability (Table 4) – and generally, two major policy recommendations are made to support universal access and service:[102]

[100] Colin Blackman and Lara Srivastava, eds., *Telecommunications Regulation Handbook* (Washington D.C. and Geneva, World Bank, InfoDev and ITU, 2011). Available at https://www.itu.int/pub/D-PREF-TRH.1-2011.
[101] Charley Lewis, *Regulating Telecommunications in South Africa: Universal Access and Service* (Cham, Palgrave Macmillan, 2020).
[102] Ibid.

- Collection of a certain amount as universal service obligations contribution from the operators through licence regulations.
- Establishment of a common pool fund commonly known as the universal service fund to financially support the provision of telecom services and infrastructures in remote, commercially unattractive and sparsely populated areas.

The regulations and policies around universal access and service are determined by a county's national vision, socioeconomic conditions and an understanding of public interest as a societal value consideration. Transnational commitments and regional cooperation also influence them. Although broad global templates of such regulations are available, individual countries are expected to assess their own social, economic and technological scenarios to adopt a suitable approach to universal access and service. Obligations of market competition and a level playing field in an open economy are genuine concerns. However, simultaneously, access to ICTs remains a social need.

Alleman and others argue that such an approach provides greater social embeddedness of the ICT services market as it constitutes a shift from industry interests (industrial policy) to the requirements of users (social policy) and citizens (participation in the government).[103] The Telecom Regulatory Authority of India has created a Universal Service Obligation Fund wherein licensee companies must contribute a five per cent share of their adjusted gross revenue.[104] The fund is utilized to support initiatives like countrywide broadband infrastructure connecting all the villages (BharatNet), installing towers in remote areas and providing ICT services in the north-east region of India.[105]

[103] James Alleman, Paul Rappoport and Aniruddha Banerjee, "Universal service: a new definition?" *Telecommunication Policy*, vol. 34, no. 1-2 (2010), pp. 86–91. Available at https://doi.org/10.1016/j.telpol.2009.11.009.
[104] The adjusted gross revenue is divided into spectrum usage charges and licensing fees, pegged between 3-5 per cent and 8 per cent, respectively. According to the Department of Telecommunications, the charges are calculated based on all revenues earned by a telecom operator, including non-telecom-related sources such as deposit interests and asset sales. Telcom operators insisted that the adjusted gross revenue should comprise only the revenues generated from telecom services, but the Supreme Court of India has upheld the definition of adjusted gross revenue calculation as stipulated by the Department of Telecommunications. Source: Jocelyn Fernandes, "Explainer: SC's decision on adjusted gross revenue to lead to Rs 92,000 crore hit for telcos", *Money Control*, 24 October 2019. Available at https://www.moneycontrol.com/news/business/explainer-what-is-adjusted-gross-revenue-and-why-has-the-agr-dispute-reached-sc-4570091.html.
[105] Rajat Asthana, "Telecom in Atma Nirbhar Bharat – Fast Forwarding Fibre," *Lokniti*, 4 August 2020. Available at https://mpp.nls.ac.in/blog/telecom-in-atma-nirbhar-bharat-fast-forwarding-fibre/.

Case Study 4: Malaysia's Universal Service Provision Fund to partially finance the national digital infrastructure plan

The national digital infrastructure plan, Jalinan Digital Negara, is designed to steer Malaysia towards greater digital connectivity by boosting the efficiency of the national infrastructure and optimizing spectrum usage. The Jalinan Digital Negara action plan, which is part of the Twelfth Malaysia Plan (2021-2025), lays the foundation for comprehensive and high-quality broadband coverage as well as prepare the country for the transition towards 5G technology.

Phase one entails enabling as many as 7.5 million premises with gigabit speed fixed-line broadband, expanding 4G mobile coverage from 91.8 per cent to 96.8 per cent in populated areas, upgrading mobile broadband speed from 25Mbps to 35Mbps, and gradual retirement of 3G networks by the end of 2021.

Phase two involves utilizing fixed wireless access and other fit-for-purpose technologies to address further gaps in the digital divide while priming for the eventual adoption of 5G once plans in phase one are achieved. The Jalinan Digital Negara initiative highlights the government's commitment to develop the infrastructure needed to facilitate broader coverage of the current-generation wireless technology across the nation, which in turn, will help expedite 5G roll-out.

Of the MYR 21 billion (USD 5.2 billion) budgeted for Jalinan Digital Negara, 40 per cent is derived from the Malaysian Communications and Multimedia Commission's Universal Service Provision Fund, while the remaining 60 per cent will be funded by industry players.

Source: Ministry of Communications and Multimedia, "Malaysia to see greater digital connectivity through JENDELA", 13 December 2020. Available at https://www.kkmm.gov.my/en/pengumuman-kkmm/233-kpkk-news/18264-bernama-13-dec-2020-malaysia-to-see-greater-digital-connectivity-through-jendela.
Photo credit: Microsoft Malaysia News Centre.

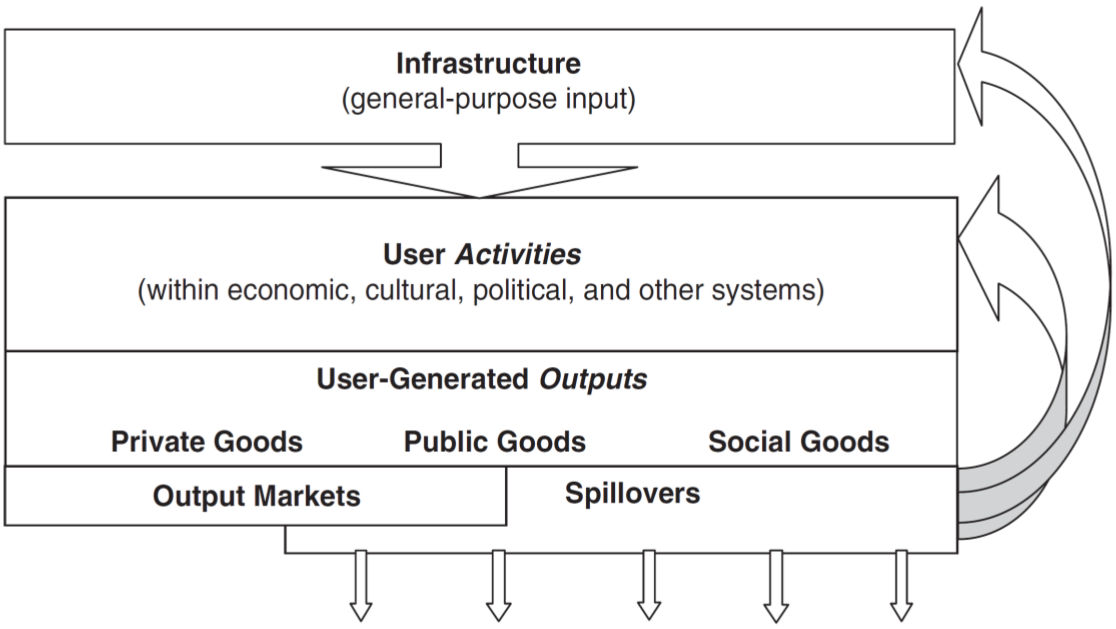
3.5 Policy Issues in Cross-Sectoral Infrastructure Sharing

A number of policy issues arise in cross-sectoral infrastructure sharing. Several social aspects beyond market competition scenarios or the usual demand-supply binaries come to the forefront. Frischmann argues in favour of the non-rival social goods that can be obtained at a marginal cost by sharing infrastructure (resources):[106]

> *For partially non-rival resources that have the finite but potentially renewable and potentially sharable capacity, the marginal cost of allowing an additional person to access and use the resource is zero over some range of demand but not necessarily overall demand. The resource is congestible, though not necessarily congested, and it may be physically depreciable, which means there may be some resource exhaustion or depletion at a rate that does not immediately transform the infrastructure but still may reduce its capacity and require maintenance or replenishment over time.*

Therefore, regulators need to calibrate the immediate consumption benefits like students from remote areas and disadvantaged communities attending online classes, and consider the long-term societal benefits of broadband connectivity like e-banking, e-marketing for local artisans, and e-delivery of government services like passport, land records and telemedicine (Figure 9).

Figure 9: Infrastructure as generic input and multifarious outputs



Source: Brett M. Frischmann, *Infrastructure – The Social Value of Shared Resources* (Oxford and New York, Oxford University Press, 2012).

[106] Brett M. Frischmann, *Infrastructure – The Social Value of Shared Resources* (Oxford and New York, Oxford University Press, 2012).

Sharing infrastructures across sectors like roads, water and gas to provide universal broadband access must be seen from an overall national, regional and global context where socioeconomic activities in any part of the world are inextricably dependent upon stable broadband connectivity (Case Study 5). Sharing these infrastructures and resources may even be offered free of cost. However, as a long-term policy decision, the costs to expand and maintain the infrastructures need to be considered.

For instance, the input (broadband connection) can be treated as a common facility for various operators to offer different services (outputs). Therefore, a good policy environment will take care of this input-output relationship to sustain connectivity in the long run. The regulators in the Republic of Korea, for example, recognize all sectoral infrastructure owners as facility management authorities, as follows:[107]

> *A common telecommunications business operator or an authority that constructs, operates or manages roads, railroads, subways, water and sewage systems, electrical equipment, telecommunications line equipment and facilities, etc. (hereinafter referred to as "facility management authority") to provide him/her with ducts, common utility conduits, poles, cables, stations, or other equipment (including telecommunications equipment and facilities; hereinafter the same shall apply) or facilities (hereinafter referred to as "equipment and facilities"), such common telecommunications business operator or such facility management authority may provide equipment and facilities by contract with him/her.*

In order to provide reliable and affordable broadband for all, the cost of broadband connectivity for the end user needs to consider not only the demand-supply scenario but also the price the users may be willing to pay for the value-added services that the broadband connection will generate as social goods. In cross-sectoral infrastructure sharing cases, these social goods or benefit considerations need to be kept in view while allowing a sector to use the assets of another. For instance, if the regulators allow a telecom operator to use the electricity poles of the power utility, or the gas pipelines, or to mount fibre-optic cables over the power transmission lines, the operator should not be strictly regarded as consumers only, but as facilitators of a networked ecosystem that will be needed to run various other activities (banking, traffic, e-commerce etc.).

[107] Telecommunications Business Act of the Republic of Korea, Act No. 11201, 17 January 2012. Available at https://elaw.klri.re.kr/eng_mobile/viewer.do?hseq=25944&type=part&key=43.

Case Study 5: Wireless@SG, Singapore

Wireless@SG was launched in December 2006 to accelerate the deployment of high-speed wireless broadband, promote wireless broadband lifestyle amongst citizens and those residing in Singapore, and catalyse the wireless broadband market in Singapore. Wireless@SG is part of the nation's ten-year masterplan called Intelligent Nation 2015. Since its launch, Wireless@SG has successfully catalysed Singapore's wireless broadband market and spawned an always-connected culture among Singaporeans.

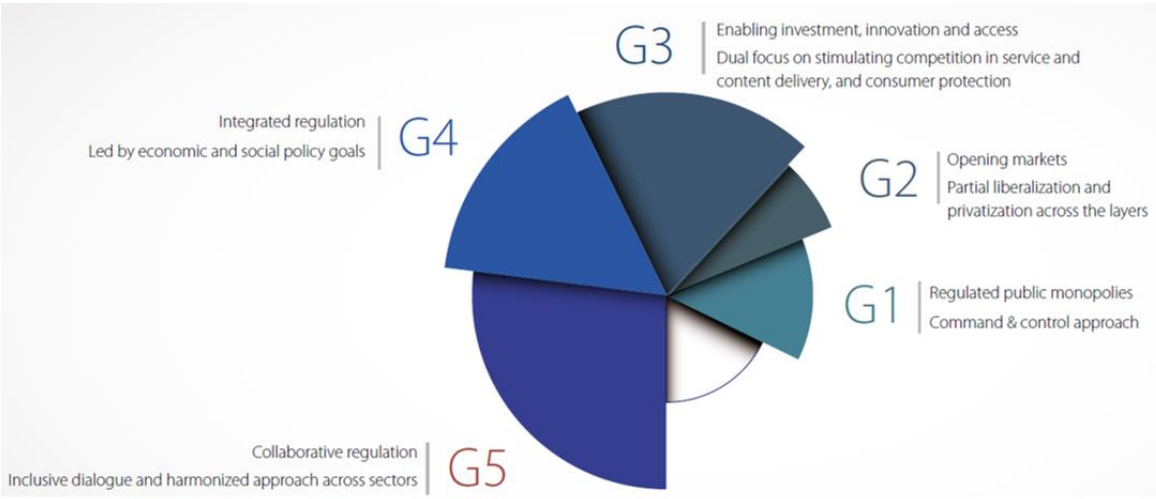
The Wireless@SG programme adopts a federated model in which Wireless@SG hotspots are sustained commercially by venue owners and Wireless@SG operators. The federated model enables seamless roaming across the Wireless@SG hotspots deployed by different operators. The Infocomm Media Development Authority, a statutory board of the Singapore government under the Ministry of Communications and Information, is the programme owner and ensures consistent user experience by stipulating standards for identity management, login and security.

Over the years, Wireless@SG has implemented several enhancements that focus on consumer experience and enterprise adoption. Some of these enhancements include the introduction of EAP-SIM that uses SIM card credentials to connect to Wireless@SG networks, launch of the Wireless@SG app to facilitate easier log on and auto connection, faster surfing speed (minimally 5Mbps), replacing login with SMS one-time password (instead of username and password) to support both local and foreign mobile numbers, and more hotspots. Hotspots are provided in public transport facilities, malls, food centres and community centres.

Sources: Infocomm Media Development Authority, "Wireless@SG". Available at https://www.imda.gov.sg/programme-listing/Wireless-At-SG; and Eng Seng Chia, "Singapore's smart nation program – Enablers and challenges", paper presented at the 11th System of Systems Engineering Conference, June 2016. Available at https://www.researchgate.net/publication/306113634_Singapore's_smart_nation_program_-_Enablers_and_challenges.

In addition to the social value considerations in infrastructure sharing, regulators are concerned with putting monetary value to these services (revenue) and sharing this among the infrastructure owners and service providers. The idea of collaborative regulation recommended by the ITU is emerging as a new framework to resolve this issue.[108] Known as fifth generation regulation, this regulatory framework incorporates personal issues like privacy, access and rights, and the collective social benefits of regulatory intervention in telecommunication. It considers the demands of market competition and the developmental needs of society. Through consultation and cooperation among the stakeholders, the regulators try to reach a common ground and leave the players to find a mutually acceptable solution rather than imposing any penalizing rule. The collaborative approach has emerged through an evolutionary process over the generations of regulatory experiences (Figure 10).

Figure 10: Generations of ICT regulation



Source: ITU, *Global ICT Regulatory Outlook 2020* (Geneva, 2020). Available at https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-BB.REG_OUT01-2020-PDF-E.pdf.

Examples above have shown different approaches to cross-sectoral infrastructure sharing. The Republic of Korea uses legal provisions to permit sharing among sectoral players. The Telecom Regulatory Authority of India has started a series of consultations with stakeholders before making specific recommendations to the government. In Bangladesh and Bhutan, the telecom regulators have already initiated infrastructure sharing with other sectors like railway, telecom and power utilities. These approaches have supported broadband co-deployment to remote areas and difficult terrains. However, a strong national vision and mission should be set to enable a collaborative approach to achieve the desired results. The teething troubles of finalizing the right set of regulations remains a challenge in many countries with contentious issues of market failures and disruption, fair competition, access, pricing and revenue sharing agreements.

[108] ITU, *Global ICT Regulatory Outlook 2020* (Geneva, 2020). Available at https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-BB.REG_OUT01-2020-PDF-E.pdf.

Regulating Over-the-Top Services

During the COVID-19 pandemic, when people were confined to homes, attention was drawn towards the accelerating growth of over-the-top (OTT)[109] service providers. OTT services thrived during the pandemic leading to phenomenal increases in video and data consumption. Brazil, for example, added more than 20 million subscribers in 2020. It is projected that streaming video on demand revenues will have a compound annual growth rate of 10.6 per cent through 2025 to become a USD 81.3 billion industry.[110] This development will have an obvious impact on telecom services and their revenue models. Telecom service providers and OTT platforms are entering into various revenue-sharing arrangements through minimum guarantee and cost-per-subscriber agreements. With an increased number of consumers and content that drive data consumption, even the assurance of minimum guarantee to the content providers of OTT seems redundant.[111]

There are ongoing discussions on regulating OTT services in different countries. The concerns are raised around substitutability of services like voice telephone, video calls and instant text messages. However, OTTs are dependent on telecom service providers for offering their services. The absence of regulatory intervention in the case of OTT services compared to the regulations on telecom service providers seems to present a non-level playing field scenario. The European Union and Australia have initiated some legal steps in this direction.[112] Some countries have adopted a restrictive approach based on existing laws, while others are discussing whether OTT services should be regulated. Most countries are not regulating OTT services yet, while others support national alternative OTT services (e.g., KakaoTalk, Line, WeChat).[113]

The increasing popularity of OTT services can drive the expansion of telecom infrastructure and quality of services as more subscribers of OTT services will generate more revenue for telecom service providers. Investment in expanding the broadband networks that will support OTT services will help return the investment by higher utilization of the network.[114] Infrastructure sharing and co-deployment approaches can help distribute investment burdens among the partners. At the same

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[109] The ITU considers OTT to be any Internet application that may substitute or supplement traditional telecom services, from voice calls and text messaging to video and broadcast services. An OTT provider is a service provider that offers ICT services, but neither operates a network nor leases network capacity from a network operator.
[110] PwC, "Power shifts: Altering the dynamics of the E&M industry – Perspectives from the Global Entertainment & Media Outlook 2021–2025", 2021. Available at https://www.pwc.com/gx/en/entertainment-media/outlook-2021/perspectives-2021-2025.pdf.
[111] Javed Farooqui, "How new market dynamics are changing the nature of telecom-OTT partnership", *Exchange4Media*, 15 February 2021. Available at https://www.exchange4media.com/digital-news/how-new-market-dynamics-are-changing-the-nature-of-telecom-ott-partnership-110920.html.
[112] See Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018; and the Telecommunications and Other Legislation Amendment (Assistance and Access) Act 2018 of Australia.
[113] Telecom Regulatory Authority of India, "Recommendations on Regulatory Framework for Over-The-Top (OTT) Communication Services", 14 September 2020. Available at https://bit.ly/39ZguTC.
[114] Telecom Regulatory Authority of India, "Consultation Paper on Regulatory Framework for Over-The-Top (OTT) communication Services", 12 November 2018. Available at https://bit.ly/3F8KxGL.

time, technology adoption, market dynamics, pricing arrangements and quality of services will impact both telecom and OTT services.[115]

3.6 Summary

Regulations are often seen as government interventions justifiable only in special circumstances like a market failure. However, with the emergence of new technologies and the convergence of technologies, utilities and services necessary to run a modern economy, it is increasingly clear that ICT is a universal service for all citizens.

Some scholars have described regulations as having three main aspects: (1) rules, regulations, guidelines, statutes and laws; (2) a general framework for steering the overall economy; and (3) social control mechanisms exerted by the state. All regulatory mechanisms have their strengths and weaknesses in policy directions, economic agendas, enforcement mechanisms and structures. Regulations and regulatory agencies are primarily concerned with public utilities like water and electricity, where incumbents hinder the market's free operations. Regulators are seen to provide confidence and transparency to market operations.

Prosser identified two major visions of regulations. One is government intervention as a measure of sheer economic efficiency. Regulators respect the private sector's autonomy, self-regulation and mutual contractual arrangements among the players. The other vision considers regulation as a joint enterprise where economic, social or distributive justice factors are considered.

Two aspects of the evolution of telecom regulations across the world may be noted here. First, the boundaries of regulations concerning infrastructure and content are now diminished with technological advancement. Second, to leapfrog ICT development, especially in developing countries, the telecom sector opened for competitive participation before the relevant regulatory frameworks could be put in place.

The phenomenal growth in ICTs, number of consumers and geographical coverage of ICT networks have increased the complexity of regulating the sector at different levels. While the market has become fiercely competitive, with multiple players vying for customers, the cost of infrastructure deployment remains high. Regulators can reduce entry barriers (like the cost of new infrastructure deployment), enabling new players to join the market to provide competition against the incumbents or dominant sectoral players.

As infrastructure sharing is one way to ease the entry of new players in the telecom sector, the regulatory concerns in such sharing attain much importance. The joint utilization of assets and services necessary to provide telecom service means the incumbent, which has built infrastructure over the years, should share its assets with a new entrant to market so that it can offer services in a competitive market.

[115] Drishti, "OTT Service Providers vs Telecom Service Providers", 19 February 2021. Available at https://www.drishtiias.com/daily-updates/daily-news-analysis/ott-service-providers-vs-telecom-service-providers.

The mandatory approach in telecom regulations considers telecommunication as an essential facility, and its access should therefore not be restricted, syndicated or monopolized in such a way as to obstruct the entry of a new player. However, mandatory infrastructure sharing is not a universal formula for all. The market needs some level of maturity and size to adopt such a policy.

The other regulatory approach in telecommunication is voluntary sharing when it is left to the infrastructure owner's choice to adopt a sharing policy based on the costs and benefits. It is recognized that the ideal competitive market in the telecom sector may not be achieved as the initial cost of infrastructure may deter new entrants from joining the competition.

With rapid changes in technology, the idea of universal access to a telephone or the Internet has undergone several changes, and today, broadband connectivity has become the bare minimum for all. With further convergence of technologies and public utility services under NGNs, ICT policymakers face new challenges in providing reliable and resilient universal broadband access and service to all. The regulations and policies around universal access and service are determined by a county's national vision, socioeconomic conditions and an understanding of public interest as a societal value consideration.

A number of policy issues arise in cross-sectoral infrastructure sharing. Several social aspects beyond market competition scenarios or the usual demand-supply binaries come to the forefront. Frischmann argues in favour of the non-rival social goods that can be obtained at a marginal cost by sharing infrastructure.

Sharing infrastructures across sectors like roads, water and gas to provide universal broadband access must be seen from an overall national, regional and global context where socioeconomic activities in any part of the world are inextricably dependent upon stable broadband connectivity. The input (broadband connection) can be treated as a common facility for various operators to offer different services (outputs). Therefore, a good policy environment will take care of this input-output relationship to sustain connectivity in the long run. In cross-sectoral infrastructure sharing, the social goods or benefit considerations must be kept in view while allowing a sector to use the assets.

In addition to the social value considerations in infrastructure sharing, regulators are concerned with putting monetary value to these services (revenue) and sharing this among the infrastructure owners and service providers. The idea of collaborative regulation recommended by the ITU, also known as the fifth generation regulation, is emerging as a new framework to resolve this issue.

3.7 Exercise: Check Your Progress

Answer the following:

1. Regulation, according to Webster's New World Telecom Dictionary, originates from the Latin word "*regula*" that means _______________.
2. In social regulation the focus is on social welfare and greater _______________.
3. The liberalization of the economies and a parallel advancement in _____________ brought the privatization movement.
4. Telecom regulations need to focus on providing ________________ as a minimum utility for all in the larger public interest.
5. To finalize a regulatory framework in any country, careful consideration of both _________ and the regulation is necessary.
6. Regulations have been seen by many as something by nature prohibitive or opposite to the idea of a ________________.
7. The _________________ aspects of regulations cover the primary concern of providing affordable quality telecom services to all.
8. With technological advancement, the boundaries of regulations concerning infrastructure and _______________ are now diminished.
9. The spectrum allotted to private companies are _______________, and hence it should be used for the welfare of all.
10. Telecom regulators need to balance their approach between mandatory and ______________ dimensions of regulations.
11. The ideal competitive market in the telecom sector may not be achieved and it can remain as an _________________.
12. Obligations of market competition and level playing field in an open economy are ________________ concerns.
13. The input (broadband connection) can be treated as a common facility that can be used by various operators to offer ____________ as outputs.
14. In addition to social value considerations in infrastructure sharing, regulators are concerned with the ______________ value of these services.
15. The overall regulatory environment that emerges supports ____________________ of elements of the telecom infrastructure.

3.8 Suggested Readings and Online Resources

1. Alleman, James, Paul Rappoport, and Aniruddha Banerjee (2010). Universal service: A new definition? *Telecommunication Policy*, vol. 34, no. 1-2, pp. 86–91. Available at https://doi.org/10.1016/j.telpol.2009.11.009.
2. Blackman, Colin and Lara Srivastava, eds. (2011). *Telecommunications Regulation Handbook.* Washington D.C. and Geneva: World Bank, InfoDev and ITU. Available at https://www.itu.int/pub/D-PREF-TRH.1-2011.
3. Infocomm Media 2025 Plan of Singapore. Available at https://www.mci.gov.sg/portfolios/infocomm-media/infocomm-media-2025.
4. ITU (2020). *Global ICT Regulatory Outlook 2020*. Geneva. Available at https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-BB.REG_OUT01-2020-PDF-E.pdf.
5. Prosser, Tony (2006). Regulation and Social Solidarity. *Journal of Law and Society,* vol. 33, no. 3, pp. 364-387. Available at https://www.jstor.org/stable/3838855.
6. Renda, Andrea (2010). Competition–regulation interface in telecommunications: What's left of the essential facility doctrine. *Telecommunications Policy*, vol. 34, pp. 23–35. Available at https://doi.org/10.1016/j.telpol.2009.11.005.

4. OPEN ACCESS: CHALLENGES AND OPPORTUNITIES

4.1 Introduction

This section discusses an open access model of the broadband network where ownership of the infrastructure and delivery of services are shared by different entities. It entails discussing how multiple service providers or operators can jointly use and share the cost of deploying and maintaining the broadband infrastructure as a common utility. Open access broadband is an alternative solution to investing in connectivity, and this section also discusses open access network business models, highlighting some potential risks in terms of conflict in competitive interest, technical compatibility and inter-party disputes. Three open network business models are examined – passive-layer open model, active-layer open model and three-layer open model.

4.2 Learning Objectives

At the end of this section, you will be able to:

- Understand the concept of open access broadband networks.
- Examine the idea of open access broadband infrastructure as a common utility.
- Explain various models of open access broadband facilities and the potential challenges in providing open access.

4.3 Open Access Broadband Infrastructure

Open access is an approach being adopted by some countries to develop broadband networks. This approach allows sharing of infrastructures, facilities or parts of a network, which may involve providing bulk access to an existing network, national backhaul, undersea cable or Internet exchange points. In the case of broadband networks, the open access policy indicates mainly the sharing of the infrastructure elements that are difficult to duplicate economically by a new player in the market and hence seen as a bottleneck for the new entrant to operate or provide services.[116]

Box 5: What is open access?

Open access is a broad approach to policy and regulatory issues that starts from the question: what do we want to bring about outside of purely industry sector concerns? It emphasizes: empowering citizens, encouraging local innovation, economic growth and investment, and getting the best from public and private sector contributions. It is not simply about making micro-adjustments to the technical rules of the policy and regulatory framework but seeking to produce fundamental changes in the outcomes that can be delivered through it.

The open access approach is about creating a set of core values that can be summarized as follows:

- A technology-neutral framework that encourages innovative, low-cost delivery to users.
- Competition at all layers in the network, allowing a wide variety of physical networks and applications to interact in an open architecture.
- Transparency to ensure fair trading within and between layers that allows clear, comparative information on market prices and services.
- The circumstances where everyone can connect to everyone else at the layer interface so that any size organization can enter the market, and no one takes a position of dominant market power.
- Devolved local solutions rather than centralized ones, encouraging services that are closer to the user.

Source: Extracted from InfoDev, *Open Access Models: Options for Improving Backbone Access in Developing Countries* (Washington D.C., World Bank, 2005). Available at https://www.infodev.org/infodev-files/resource/InfodevDocuments_10.pdf.

Countries and their regulators differ in defining their open access policy. For example, in fixed-broadband networks, especially digital subscriber lines, the focus is on local loop unbundling as an infrastructure sharing mode and an open access policy. Broadband networks have evolved as an NGN that incorporates key architectural changes in telecom networks that carry all information and services (voice, data and

[116] In an open access policy, the incumbent companies or monopolies that own major telecom infrastructure will be mandated to give access to their facilities for new or competing businesses that do not own physical infrastructure. In the telecom sector, a bottleneck is created when a telecom operator exerts natural monopolistic dominance over infrastructure or services that are financially difficult to duplicate but essential for other players to operate in the sector.

all sorts of media such as video). In the case of NGN, the open access policy provides more technology choices and provides an alternative approach to infrastructure deployment that will promote more competition in the broadband sector. Different strategies have been adopted to promote infrastructure sharing to expand broadband connectivity to unserved and underserved areas, and these strategies have their pros and cons (Table 5).

Table 5: Pros and cons of different broadband strategies

Broadband strategy	**Pros**	**Cons**
Infrastructure sharing	• Encourages competition between broadband services for consumers • Reduces market power of major market players	• Reduces incentive of investment if the access price is too low • High regulatory cost
Infrastructure competition	• Encourages competition between broadband infrastructures • Encourages innovation and technology	• High cost of infrastructure duplication • Abuse by important market players if there is not enough competition
Public funding/public-private partnership	• Guarantees the broadband infrastructure in the long run • No barrier to new entrants by incumbents	• Does not solve the incentive to invest problem • Public funding can instead be used in other projects

Source: Chatchai Kongaut and Erik Bohlin, “Unbundling and infrastructure competition for broadband adoption: Implications for NGA regulation”, *Telecommunications Policy*, vol. 38, no. 8-9 (2014), pp. 760–770. Available at http://dx.doi.org/10.1016/j.telpol.2014.06.003.

In addition to expanding broadband access in unserved and underserved areas, this access needs to be affordable for end users, particularly in developing country contexts. Achieving affordability requires a critical mass of end users (consumers), while lowering the cost of broadband helps gather such a critical mass of end users to generate further interest among the operators to enhance their services.

Evidence shows that the presence of several competing players in the market leads to lower connectivity costs, and in countries where a limited number of players dominate the market, the cost of broadband tends to be higher.[117] These findings provide justification for countries to open up access to broadband networks – like the national highways. It is important that regulators find ways to generate interest in opening access to broadband networks, allowing players to provide services to

[117] Tracy Cohen and Russell Southwood, “Extending Open Access to National Fibre Backbones in Developing Countries”, a discussion paper for ITU’s Eighth Global Symposium for Regulators, 2008. Available at https://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR08/discussion_papers/Cohen_Southwood_web.pdf.

citizens on these networks at a competitive price. Benefits include boosting global competitiveness and bridging the digital divide.[118]

In cross-sectoral infrastructure sharing, open access can be a policy option where various opportunities to share the backbone, physical infrastructures, and passive and active elements of the broadband networks can be explored. Traditional sectoral players like telephone, water, electricity or power utilities with their fibre-optic networks and physical infrastructures can open themselves to act as infrastructure providers and allow other service providers to access their networks. Once the incumbents see the additional revenue from infrastructure sharing with other sectors and telecom operators based on open access, they will welcome such policies. The open access policy will also encourage new entrants and service providers to enter the market.[119] In the long run, this will lead to cheaper broadband access for all citizens.

The broader objective behind an open access policy is to convert telecom facilities into a public good available to all. With a nudge from the governments and the regulators in that direction, it is expected that the market will ultimately deliver ICT services to those at the bottom of the income pyramid by lowering the cost of services.[120] In a multi-layered scenario, open access will generate competition in all layers connected in a technology-neutral framework that encourages innovative, low-cost delivery to users (Box 6).

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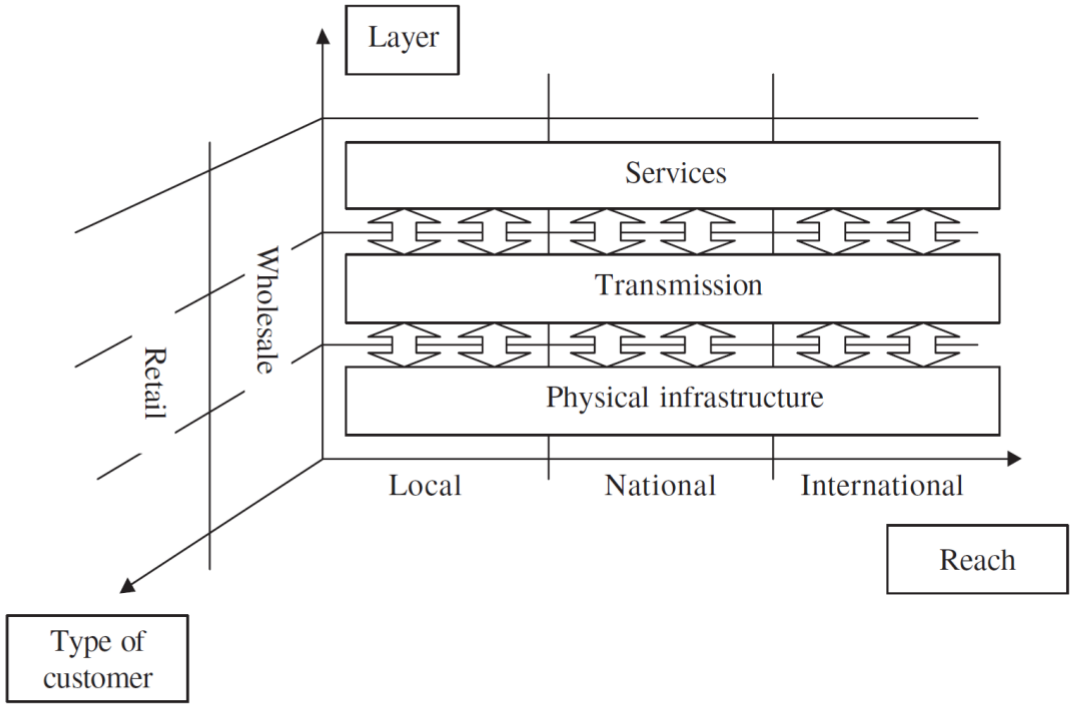
[118] Chatchai Kongaut and Erik Bohlin, “Unbundling and infrastructure competition for broadband adoption: Implications for NGA regulation”, *Telecommunications Policy*, vol. 38, no. 8-9 (2014), pp. 760–770. Available at http://dx.doi.org/10.1016/j.telpol.2014.06.003.

[119] Ibid.

[120] InfoDev, *Open Access Models: Options for Improving Backbone Access in Developing Countries* (Washington D.C., World Bank, 2005). Available at https://www.infodev.org/infodev-files/resource/InfodevDocuments_10.pdf.

Box 6: Layered networks model



The diagram above shows a layered networks model. Essentially, there are three key layers: physical infrastructure, transmission and services (including applications and content). Each layer has a set of functional rules that allows it to interface with the other layer and for information to flow over the network. In day-to-day reality, these network functions are combined with reach (the geographic scope of providers) and type of customer (wholesale or retail). The interface between layers is technically standardized by protocols and commercially agreed in service level agreements and other businesses and contract commitments. The latter tends to be standardized as the number of actors grows. For example, one player on the transport layer can rent fibre from several dark fibre providers to span its network and will need similar performance standards from each to simplify its offer to the service layer.

Source: Extracted from InfoDev, *Open Access Models: Options for Improving Backbone Access in Developing Countries* (Washington D.C., World Bank, 2005). Available at https://www.infodev.org/infodev-files/resource/InfodevDocuments_10.pdf.

4.4 Common Utility and Multiple Operators in Open Access

In Section 3.5, it was indicated that sharing infrastructure among different sectors to provide broadband facilities to all populations in a country can be related to the idea of a common utility or a social good.[121] Internet service providers were traditionally the network infrastructure owners and the only providers for Internet services. In the open access model, this arrangement is not followed – ownership of the infrastructure (fibre, towers, power stations, etc.) is separated from the offering of services (e.g., Internet). This means multiple service providers or operators can access a shared infrastructure.[122] Therefore, multiple infrastructure owners (operators) can join hands and provide their networks to new service providers who need not build their infrastructure. With multiple players in the market, consumers can have better services, more options and more competitive pricing.[123]

There are three major management and pricing challenges in sharing of infrastructure among a diverse set of cross-sectoral owners: (1) price discrimination, (2) shared management and price regulation, and (3) infrastructure pricing.[124] To resolve these challenges, and manage and operate a shared infrastructure built on partnership across the sectors, a set of principles may be followed. ITU recommends these principles drawing from best practices. These principles are also validated through surveys.[125] These principles are:

- **Inclusive regulatory framework** – Policy clarity, coverage of all concerns and transparency in implementation attract both investment and infrastructure sharing. Hence, any regulatory framework must cover all relevant issues concerning all sectoral players and all aspects of such sharing. Focusing partially on passive infrastructure or any specific needs of only a particular sector will deter potential sharing partners. A different set of regulators, acting solo, can also make the sharing complicated. Therefore, the involvement of all sectors in developing a common regulatory framework is necessary for synergizing cross-sectoral governance, processes, standards and systems. For example, a single regulatory agency is responsible for multiple sectors in countries like the Gambia (Public Utilities Regulatory Authority) and Rwanda (Utility Regulatory Authority).[126]

- **All types of sharing should be permitted** – Selective adoption of infrastructure sharing in a piecemeal manner is detrimental to both competition and potential investment in the sector. All types of infrastructure sharing should be permitted with clear guidelines and subject to compliance with competition laws. India and Malaysia, for instance, have a comprehensive set of guidelines for infrastructure sharing among all sectors.

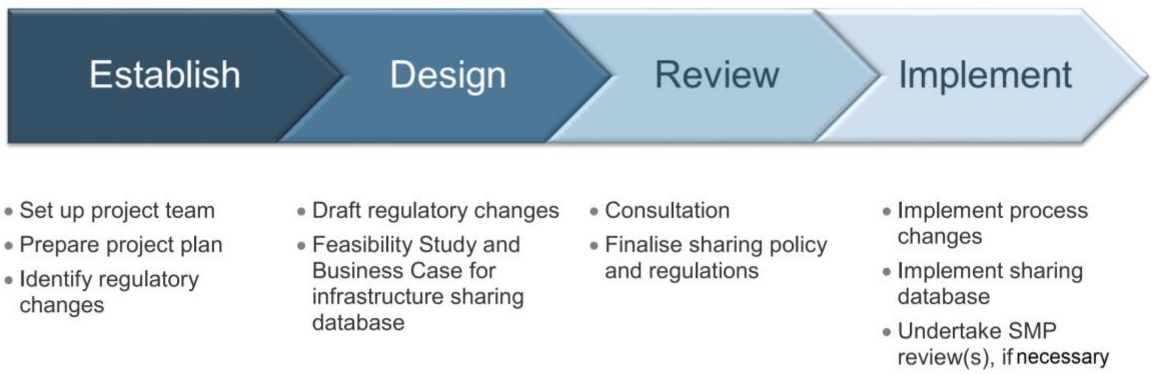
[121] Brett M. Frischmann, *Infrastructure – The Social Value of Shared Resources* (Oxford and New York, Oxford University Press, 2012).
[122] Underline, "Intro to Fiber, Open Access, "Broadband", 5G", 8 April 2020. Available at https://underline.com/post/intro-fiber-open-access-broadband-5g.
[123] Ibid.
[124] Brett M. Frischmann, *Infrastructure – The Social Value of Shared Resources* (Oxford and New York, Oxford University Press, 2012).
[125] Communications Regulators' Association of Southern Africa and ITU, "ICT and Broadcasting Infrastructure Sharing Guidelines", 21 February 2016. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/CRASA-ITU-IS_Guidelines_Final_Jan2018.pdf.
[126] Ibid.

- **Right to request for sharing and obliging such request by sectors** – Regulatory authorities should identify the specific aspects that are mandatory to share across sectors. Once these aspects are identified, it will confer a right on the players to request such sharing partnerships. In turn, the receiver of the request will also be obliged to respond and negotiate such sharing arrangements in a time-bound manner. Standard agreements and acceptable reasons for denial of partnerships may also be provided.

- **Infrastructure sharing should be transparent, fair and non-discriminatory** – The regulatory framework should define the processes, principles of negotiations and the acceptable timeframe to work out potential infrastructure sharing. Pricing guidelines on how pricing should be fair, economically viable and non-discriminatory are needed to reduce future disputes, especially in cases of significant market power.

- **Dispute resolution and national mission** – Any infrastructure sharing policy should include a time-bound dispute resolution mechanism. Further, to sustain such sharing, the infrastructure sharing policy should be prepared in tandem with the national broadband strategy, with the availability of funds (e.g., universal service fund) to support sharing in remote areas and the deployment of emerging technologies.

Figure 11: Participatory approach to cross-sectoral infrastructure sharing



Note: SMP = significant market power
Source: Communications Regulators' Association of Southern Africa and ITU, "ICT and Broadcasting Infrastructure Sharing Guidelines", 21 February 2016. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/CRASA-ITU-IS_Guidelines_Final_Jan2018.pdf.

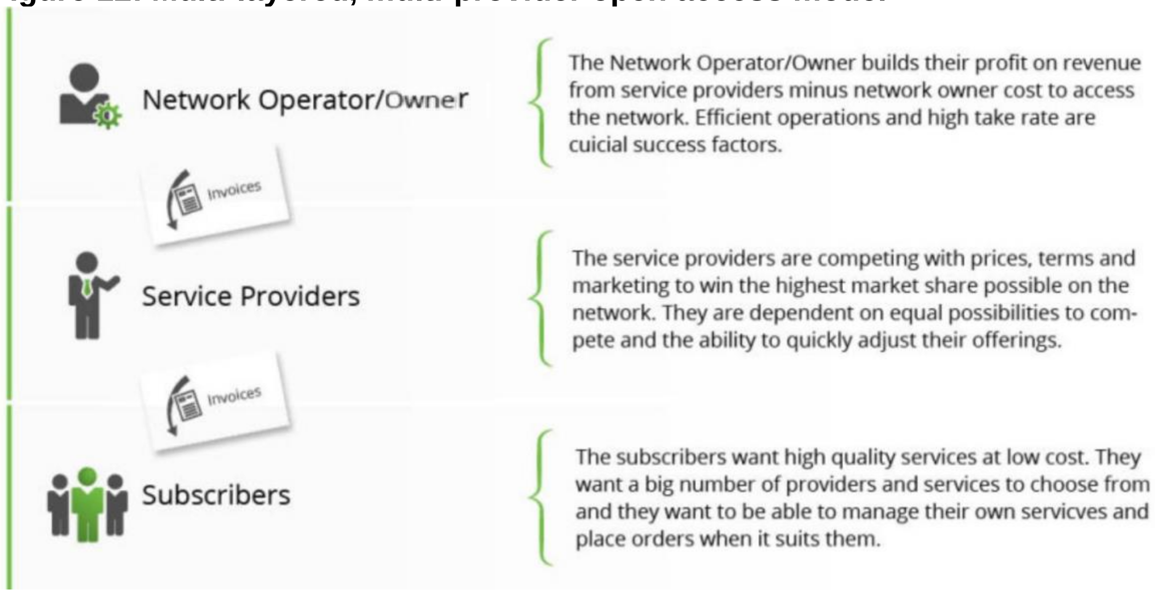
Cross-sectoral infrastructure sharing, especially on an open access basis, has many managerial and regulatory challenges. For instance, the sectoral infrastructure owners may not aspire to become telecom service providers at the last mile but can provide access to their available bandwidth in bulk. Since the early 1990s in Europe and other countries, many regulators, operators and other stakeholders have come together on an open access basis by separating infrastructure and services. A consultative cross-sectoral approach may be followed to reach an arrangement that incorporates some of the principles discussed above (Figure 11).

4.5 Business Models of Open Access Broadband

In the traditional business model for broadband, when used for very limited email and Internet surfing purposes, the subscriber used to get a specific amount of bandwidth "by the bucket"[127] defined by specific upper limit fees per month. When the consumer used this bucket, it was refilled at a cost. Initially, the model worked fine as the bucket was rarely fully utilized by the user. More recently, with the introduction of data-intensive online services and streaming videos, larger buckets were offered and refilled at a cost. Simultaneously, different networks came up at the same locations – with wireless broadband networks and the old copper (digital subscriber line) networks running side by side. These duplications of networks increase the cost for the end user as providers need to recover the network infrastructure costs.

In the open access model, a high-speed and resilient network is built, and all service providers use the same network by paying a fee and offering their services to the end users or customers. Customers can pay for the services of their choice from one or multiple providers at a competitive price. Here, many service providers share the network's cost, and hence, lowers the cost for customers. The network owner or its operator is focused on the smooth functioning of the network, while the service providers are concerned with new offerings, quality of service and competitive price.

Figure 12: Multi-layered, multi-provider open access model



Source: COS Systems, "Open Access". Available at https://www.cossystems.com/about/open-access/.

[127] Andrew Cohill, "The Economics of local transport services over open access networks", *ICT Solutions and Education*, 21 March 2019. Available at https://www.isemag.com/2019/03/municipal-broadband-open-access-broadband-networks.

There are two types of open access arrangements – the two-layer open access model and the three-layer open access model. In a two-layer system, one entity is both the network infrastructure owner and the operator, and multiple service providers use the network to deliver services to the consumers. In the three-layer system, the network infrastructure is owned by one entity – a company, a public sector agency or the government. The operations and maintenance of the network are given to a second party (layer), and the service providers form the third layer (Figure 12).

The billing arrangements that are commonly used in open access networks can be described as follows:[128]

- The service provider bills the subscriber for the service.
- The owner and operator bills the service provider for allowing the service provider to deliver service on the network.
- In a three-layer network, the network owner bills the operator for the right to operate on their network. Sometimes, the operator also bills the network owner for the daily maintenance of the network and provisioning of services.

An open access broadband network across sectors can be useful for supporting sectoral operations and services to monitor traffic, power supply, water supply systems, operate security cameras or collect real-time data from various sources at a much lower cost or even free of charge. The emerging smart city applications and controls will depend heavily on common broadband networks among the sectoral agencies.[129] The intelligent transportation system of Seoul, Republic of Korea is an example where real-time traffic control and automatic data collection of the urban expressways is done through the high-speed fibre-optic network operated by the Korea Expressway Corporation.[130]

It should be noted that, in the case of cross-sectoral infrastructure sharing, many sectoral players have shown reluctance to share their resources with others, and were compelled to share by law. There seem to be some trust issues between parties where the incumbent infrastructure owners do not see the partners as value but only as competitors (Box 7).[131]

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[128] COS Systems, "Open Access". Available at https://www.cossystems.com/about/open-access/.
[129] Andrew Cohill, "The Economics of local transport services over open access networks", *ICT Solutions and Education*, 21 March 2019. Available at https://www.isemag.com/2019/03/municipal-broadband-open-access-broadband-networks.
[130] Seoul Solution, "Seoul's Intelligent Traffic System (ITS)", 25 January 2018. Available at https://www.seoulsolution.kr/en/content/6536.
[131] InfoDev, *Open Access Models: Options for Improving Backbone Access in Developing Countries* (Washington D.C., World Bank, 2005). Available at https://www.infodev.org/infodev-files/resource/InfodevDocuments_10.pdf.

Box 7: Trust between service and infrastructure providers

One of the major issues in an open access business model is that it requires trust among parties. A service provider potentially puts its business at risk through trusting another provider to supply the required infrastructure. The service provider needs to be assured that the infrastructure provider is going to tackle its needs with the same degree of attention as if the organization was doing it itself. The fundamental factors for assessing this are no different from any other areas of business. They include financial stability, operational capability, gradual development of the offer and a reasonable price. The two keystone business practices for establishing trust are non-discriminatory pricing and no competition from the infrastructure provider itself.

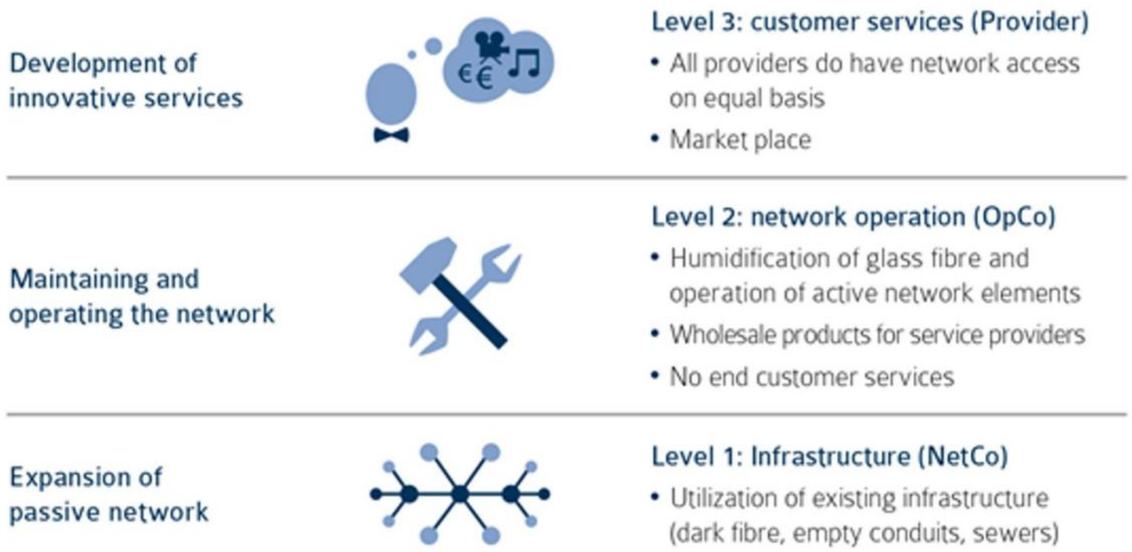
Trust is easier to establish if there is a sense of mutual interdependency. This is why alternative infrastructure providers can succeed: they are focused, know who they depend on and are eager to be cost effective as they need to acquire new customers. The service providers also know this. Mutual self-interest means that each side needs the other to succeed. In contractual terms, there are service level agreements that have been developed out of fibre lease and capacity sales deals between service providers and infrastructure companies. These address the detailed conditions and actions between the two parties should conflicts arise. Once trust is established, however, these are rarely called upon.

Source: Extracted from InfoDev, *Open Access Models: Options for Improving Backbone Access in Developing Countries* (Washington D.C., World Bank, 2005). Available at https://www.infodev.org/infodev-files/resource/InfodevDocuments_10.pdf.

As indicated above, the business models for an open access broadband network will depend on partnerships, market conditions, regulatory environment (to build trust) and different actors' roles. Different business models define various actors' roles in the broadband value chain (Box 8).[132] There are two business models – vertically integrated model and open network model. Depending on the roles played by the physical infrastructure provider, network provider and service provider, these business models are determined in a particular market.[133]

[132] European Commission, "Broadband value chain, actors and business models". Available at https://ec.europa.eu/digital-single-market/en/broadband-business-models.
[133] European Commission, "Shaping Europe's digital future – Broadband: Basic business models". Available at https://ec.europa.eu/digital-single-market/en/basic-business-models.

Box 8: Broadband value chain



A broadband network consists of three layers: passive infrastructure, active equipment technology and delivery of services. The three layers are characterized by different technical and economical features. These layers are:

- Layer 1 – Building and operating of the passive infrastructure (network set-up).
- Layer 2 – Building and operating of the active infrastructure (network operation).
- Layer 3 – Offer and distribution of services (services).

The three layers depend on each other, meaning that Layer 2 can only be realized upon completion of Layer 1, and Layer 3 requires the infrastructure from Layer 2.

Source: European Commission, "Broadband value chain, actors and business models". Available at https://ec.europa.eu/digital-single-market/en/broadband-business-models.

Vertically Integrated Model

If one actor, like a telecom company, plays all three roles described above – physical infrastructure provider, network provider and service provider – this type of business model can be termed vertically integrated. Here, incumbent telecom operators usually own the infrastructure, both active and passive, and offer services directly to the end users. Sometimes, they offer wholesale or bulk access to their network or infrastructure to competing service providers. When these players gain significant market power, regulatory bodies often compel them to open their networks to other competitors to facilitate the entry of new players and generate competition in the market.[134]

[134] Although sometimes incumbents refer to this model as "open access", this is in fact a vertically integrated model with unbundling - either at the physical layer, called local loop unbundling or at the

Open Network Model

In an open network model, the three roles are separated and different actors take up these roles. In this model, the infrastructure is common and it is open to all market players on a non-discriminatory basis. Depending on the two-layer or three-layer set-up, the network owner can take up roles of infrastructure provider and/or network provider. Based on these choices, three open network business models emerge:[135]

1. Passive-layer open model
2. Active-layer open model
3. Three-layer open model

Passive-Layer Open Model

In the passive-layer open model, an entity (government or private company) or a consortium of sectoral players builds and operates the passive infrastructures (fibre, copper or antenna sites and wireless frequency bands), and offers them to all other market actors in a fair and non-discriminatory manner. Here, the physical infrastructure provider owns and maintains the passive infrastructure, and the broadband network is open to service providers to deliver services to the end users. Sometimes, a local operator is employed to collect access fees from service providers. End users may or may not pay the access fee in the form of a one-off connection fee and/or a monthly network fee. But like in all other open network models, the end users choose the services from their service providers of choice for a service fee.[136]

The passive-layer open model gives the network operators the freedom to plan their access network. Still, each operator accessing the backbone infrastructure must deploy active equipment or enter into a sharing agreement. This model is not suitable for remote areas where the number of consumers is limited. This model, however, is viable for urban areas with a huge population, thus, many municipal and city bodies use this model to deploy backbone infrastructures like the Stockholm fibre network[137] and UTOPIA Fiber.[138]

Active-Layer Open Model

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active layer, called bitstream access. Source: European Commission, “Shaping Europe’s digital future – Broadband: Basic business models”. Available at https://ec.europa.eu/digital-single-market/en/basic-business-models.

135 European Commission, “Broadband value chain, actors and business models”. Available at https://ec.europa.eu/digital-single-market/en/broadband-business-models.

136 Ibid.

137 Stokab is owned by the City of Stockholm and is an independent provider of passive infrastructure in the form of optical fibres (dark fibre), with no active termination equipment. Source: Stokab. Available at https://stokab.se/en/stokab.

138 UTOPIA (Utah Telecommunication Open Infrastructure Agency) Fiber is a group of 16 Utah cities that joined together in 2004 to build, deploy and operate a fibre-to-the-home network to businesses and households in their communities. Using an active Ethernet infrastructure and operating at the wholesale level, UTOPIA is considered an open access network and promotes competition in all telecom services. Source: UTOPIA Fiber. Available at https://www.utopiafiber.com.

In the active-layer open model, the infrastructure provider and network provider (operator) roles are joined, and the one actor (entity) provides both passive and active infrastructure to the service providers. All service providers pay fees to access the infrastructure, and in turn, they collect a service fee from the end users. However, sometimes the infrastructure provider/operator can also collect fees from end users directly like in the passive-layer open model.

Three-Layer Open Model

In the three-layer open model, all the three roles (layers) – physical infrastructure provider, network provider and service provider – are separated. Although the infrastructure owner (active layer) may be a government or public utility, the network provider role (passive layer) is assigned to a separate entity. The network provider deploys the active infrastructure that all service providers can access (third layer). Regulators typically prohibit the network provider from delivering its own services. The non-discriminatory nature of the network provider is ensured, and all the service providers can access the network in a neutral environment. The end users generally pay a service fee that includes the network fee that goes to the network provider. Sometimes this network fee is paid directly to the network provider as a connection fee by the end user. For example, in Oman, the wastewater utility Haya Water deployed a fibre-optic network alongside their installations to create a nationwide network. But in 2013, Oman Broadband took over Haya Water's telecom operations as a broadband network provider.[139]

[139] World Bank, *Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps* (Washington, D.C., 2019). Available at http://documents1.worldbank.org/curated/en/674601544534500678/pdf/Main-Report.pdf.

4.6 Summary

This section discussed the open access model of the broadband network where ownership of the infrastructure and delivery of services are shared by different entities. The section also discussed the open access networks as common infrastructure and explored the different business models of open access broadband.

The open access policy promotes sharing of the infrastructure elements at different levels (layers) to increase competition in the broadband sector, expand broadband connectivity to unserved and underserved areas, improve ICT service quality, and reduce the cost of broadband connectivity and ICT services for end users.

In cross-sectoral infrastructure sharing, open access can be a policy option where various opportunities to share the backbone, physical infrastructures, and passive and active elements of the broadband networks can be explored. The broader objective behind an open access policy is to convert telecom facilities into a public good available to all.

In the open access model, a high-speed, resilient broadband infrastructure is built, and all service providers use the same network by paying a fee and offering their services to the end users or customers.

There are two types of open access arrangements – the two-layer open access model and the three-layer open access model. In a two-layer system, one entity is both the network infrastructure owner and the operator, and multiple service providers use the network to deliver services to the consumers. In the three-layer system, the network infrastructure is owned by one entity – a company, a public sector agency or the government. The operations and maintenance of the network are given to a second party (layer), and the service providers form the third layer.

There are two business models for open access broadband – vertically integrated model and open network model. Depending on the roles played by the physical infrastructure provider, network provider and service provider, these business models are determined in a particular market. If one actor, like a telecom company, plays all three roles listed above, this type of business model can be termed vertically integrated. If the three roles are separated, and different actors take up the three roles, this is termed the open network model. Depending on the two-layer or three-layer set-up, three open network business models exist:

1. Passive-layer open model
2. Active-layer open model
3. Three-layer open model

In the passive-layer open model, an entity (government or private company) or a consortium of sectoral players builds and operates the passive infrastructures, and offers them to all other market actors in a fair and non-discriminatory manner. The passive-layer open model gives the network operators the freedom to plan their access network. Still, each operator accessing the backbone infrastructure must deploy active equipment or enter into a sharing agreement.

In the active-layer open model, the infrastructure provider and network provider (operator) roles are joined, and the one actor (entity) provides both passive and active infrastructure to the service providers. All service providers pay fees to access the infrastructure, and in turn, they collect a service fee from the end users.

In the three-layer open model, all the three roles (layers) – physical infrastructure provider, network provider and service provider – are separated. Although the infrastructure owner (active layer) may be a government or public utility, the network provider role (passive layer) is assigned to a separate entity. The network provider deploys the active infrastructure that all service providers can access (third layer). Regulators typically prohibit the network provider from delivering its own services. The non-discriminatory nature of the network provider is ensured, and all the service providers can access the network in a neutral environment.

4.7 Exercise: Check Your Progress

Answer the following:

1. Open access policy allows a new entrant to the market to have open access to the ______________ networks.
2. Broadband networks that carry voice, data and all sorts of media such as video are known as ______________ networks.
3. For broadband, a _____________ mass of consumers is necessary to achieve affordability in terms of economies of scale.
4. The broader objective behind an open access policy is to convert telecom facilities as a _____________ good.
5. Selective adoption of infrastructure sharing in a piecemeal manner is _______________ to both competition and potential investment.
6. Duplication of networks actually ____________ the costs for the end user as the providers need to recover the costs.
7. There are two types of open access arrangements – the two-layer open access model and the _________ open access model.
8. When players seem to have significant ________________, regulatory bodies often compel them to open their networks to competitors.
9. In the open network model, the infrastructure is common and it is open to all other market players on a _________________ basis.
10. In the passive-layer open model, the network operators enjoy the ________________ to plan their access network.
11. In the active-layer open model, the infrastructure provider and network provider (operator) roles are ___________.
12. In the three-layer open model, all the three roles (layers) – physical infrastructure provider, network provider and service provider – are _______________.
13. Regulatory authorities should identify the _____________ of a network that is mandatory to share across sectors.
14. Any infrastructure sharing policy should clearly include a _____________ dispute resolution mechanism.
15. Cross-sectoral infrastructure sharing, especially on an open access basis, has many managerial and ______________ challenges.

4.8 Suggested Readings and Online Resources

1. Cohen, Tracy and Russell Southwood (2008). Extending Open Access to National Fibre Backbones in Developing Countries. A discussion paper for ITU's Eighth Global Symposium for Regulators. Available at https://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR08/discussion_papers/Cohen_Southwood_web.pdf.
2. Communications Regulators' Association of Southern Africa and ITU (2016). ICT and Broadcasting Infrastructure Sharing Guidelines. 21 February. Available at https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Infrastructure_portal/CRASA-ITU-IS_Guidelines_Final_Jan2018.pdf.
3. Frischmann, Brett M. (2012). *Infrastructure – The Social Value of Shared Resources*. Oxford/New York: Oxford University Press.
4. InfoDev (2005). *Open Access Models: Options for Improving Backbone Access in Developing Countries*. Washington D.C., World Bank. Available at https://www.infodev.org/infodev-files/resource/InfodevDocuments_10.pdf.
5. Thakur, Kishore Kumar, Satya N. Gupta, and Keshav Sharma (2020). Everything on Tower (EoT) – Enabling Broadband Access in Rural Areas Through License-Exempt Spectrum – Making the Business of Rural Broadband Happen. *Nordic and Baltic Journal of Information and Communications Technologies*, vol. 1 (2021), pp. 215-236. Available at https://www.riverpublishersjournal.com/index.php/Nbjict/article/view/2675/1903.
6. World Bank (2019). *Innovative Business Models for Expanding Fiber-Optic Networks and Closing the Access Gaps*. Washington, D.C. Available at http://documents1.worldbank.org/curated/en/674601544534500678/pdf/Main-Report.pdf.

5. MODELS OF INFRASTRUCTURE SHARING

5.1 Introduction

The module started with a history of infrastructure sharing followed by a discussion on operationalizing cross-sectoral infrastructure sharing. Recognizing the economic and social benefits of infrastructure sharing to expand the reach of broadband connectivity in a country, the policy and regulatory issues in cross-sectoral infrastructure sharing was examined. This section starts with a brief discussion of different business models for infrastructure sharing and the roles of different players in rolling out the broadband network. The section also provides some case studies covering the following three types of business models prevalent today in different parts of the world: (1) infrastructure asset sharing; (2) infrastructure mutualization; and (3) infrastructure cooperation.

5.2 Learning Objectives

At the end of this section, you will be able to:

- Understand the major business models of infrastructure sharing.
- Explain the idea of cooperation and collaboration among the sectoral players towards implementing accessible and affordable broadband for all.
- Highlight various examples of infrastructure sharing in different countries.

5.3 Roles of Different Players in Infrastructure Sharing

Infrastructure sharing requires the involvement of sectoral entities. As mentioned in Section 1, the railway operators supported the roll out of telegraph facilities. Today, roll out of the telecom infrastructure requires similar support from roadways, railways, water and sewerage systems, electricity grid, and oil and gas pipelines to carry fibre-optic cables. It is increasingly being accepted that in order to make the modern broadband facility, both accessible and affordable for all, cross-sectoral infrastructure sharing is needed. This can involve the sharing of physical facilities (e.g., use of utility poles to carry fibre-optic cables) or the sharing of available telecom facilities to provide broadband services to the larger public (e.g., Bangladesh Railways' lease of fibre-optic network to Grameenphone).

As cross-sectoral infrastructure sharing requires the active support and cooperation of different infrastructure owners, it is important to discuss their roles in such arrangements. Major roles that are played by the sectoral entities are that of: (1) carrier of the telecom infrastructure; (2) facilitator for expansion of national ICT infrastructure plans; (3) generator of additional revenue; and (4) operator and caretaker of a network (backbone).

As carriers of the telecom infrastructure, sectoral players can allow their physical assets, right of way, corridors, ducts, conduits, poles and towers to carry telecom installations, equipment and fibre-optic cables of a telecom service provider. Traditionally, roadways, railways, power transmission lines, and sewerage and water pipelines deploy their own fibre-optic networks. Here, a telecom operator uses a sectoral entity's facilities, corridors and installations to carry its network. In India, for example, a telecom licensee is, by law, authorized to have the right of way along railways and roadways. A telecom operator can install its telecom networks on the land legally owned by others through mutual sharing arrangements and permissions. This sometimes leads to complications when the infrastructure owner charges unreasonably high rent, or when a telecom licensee damages the infrastructure while installing its cables. While policymakers may offer the right of way to the telecom licensee in the larger public interest, the same gesture may not be shared by other sectors. Therefore, it is important to reach consensus among the sectoral players that telecom facilities are a social common, and all sectoral authorities should play the role of carriers of the telecom infrastructure.

Several countries have developed national plans, missions and strategies to build a national ICT infrastructure backbone. The provision of reliable, resilient and high-speed broadband connectivity is essential for all socioeconomic activities today. Here, the different sectoral entities are expected to play the role of facilitator in implementing a national broadband mission. By sharing their sectoral (internal) telecom infrastructure (active and passive), especially their unused bandwidth (dark fibre), sectoral players can facilitate a quicker, economical and faster roll out of a national broadband network. In India, for example, the National Optical Fibre Network is facilitated by three prominent sectoral players – telecommunication, railways and the power grid – through a tripartite memorandum of understanding to connect all villages in the country to a national broadband network. All service providers like telecom service providers, Internet service providers, cable television operators and others are given non-discriminatory access to the network to offer their services to the public.[140] Also in India, Bombay Gas has created CloudExtel, which offers fibre network facilities to telecom operators in South Mumbai. It is building advanced infrastructures like managed backhaul, small cells and shared microsites in the city.[141] In another case, Bhutan Telecom joined hands with Bhutan Power Corporation to build the national backbone network by deploying optical ground wire cables over power transmission lines.[142]

Sectoral entitles can also play the role of revenue generators through infrastructure sharing (Box 9). A sectoral infrastructure owner like the railway operator, whose core business is not telecommunication, can generate revenue by sharing its infrastructure with other telecom operators.[143] This includes leasing out unused bandwidth or existing infrastructure. Infrastructure owners can then use these earnings to recover their investment in infrastructure or pay for the maintenance of their facilities. At the same time, the sectoral infrastructure owner can drive competition by easing the entry of new players (telecom service providers) since they will not need to build the infrastructure themselves. Infrastructure sharing can generate savings of 30 to 40 per cent in CapEx and OpEx.[144]

[140] Bharat Broadband Network Limited is a special purpose vehicle set up to create the National Optical Fibre Network in India. A total of around 250,000 village councils are to be covered by laying incremental fibre. For details see http://www.bbnl.nic.in.
[141] CloudExtel, a Bombay gas venture, is an established company providing fibre network services to telecom operators. For details see http://www.cloudextel.com.
[142] ESCAP, "ICT Co-Deployment with the Electricity Infrastructure: The Case of Bhutan", Asia-Pacific Information Superhighway (AP-IS) Working Paper Series, June 2019. Available at https://www.unescap.org/resources/ict-co-deployment-electricity-infrastructure-case-bhutan.
[143] World Bank, “Cross-Sector Infrastructure Sharing Toolkit”. Available at https://ddtoolkits.worldbankgroup.org/infra-sharing.
[144] Vaishali Rastogi and others, “A $2 Trillion Plan to Bring Two Billion More People into the Digital Age”, *Boston Consulting Group*, 11 September 2020. Available at https://www.bcg.com/en-in/publications/2020/plan-to-bring-high-speed-internet-access-to-two-billion-people.

Box 9: Examples of infrastructure owners generating revenue from their telecom systems

China: The China TieTong Telecommunications Corporation was established in late 2000 to integrate and improve the telecom systems of Chinese railways. After upgrading the network, China TieTong was transferred from the Ministry of Railways to the State-owned Assets Supervision and Administration Commission of the State Council in 2004, when it started offering a variety of ICT services to the public and the business sector, as well as to Chinese railway systems. Its fibre network, running along railway tracks, is more than 100,000 km long and extends over all the country's provinces, including most major cities.

India: RailTel Corporation has emerged as one of the largest telecom infrastructure providers in India by leasing its unused fibre. In the process, RailTel has diversified its revenue incomes and achieved robust profit margins, part of which are being reinvested in infrastructure upgrades and maintenance.

Philippines: In Manila, the rights of way provided by the Manila Metro Rail Transit System and Manila Light Rail Transit System have been utilized by the Integrated Government Project to lay fibre-optic cables. This project aims to interconnect public offices with fibre in Manila for information sharing and the delivery of common applications among users.

Russian Federation: TransTelekom is a subsidiary of Russian Railways, the national railway operator. It uses fibre deployed along Russian railways to provide a variety of ICT services, including retail and wholesale services. It reaches out to the provincial market, with people living in settlements of fewer than 100,000 inhabitants, accounting for almost 40 per cent of all connections. In addition, TransTelekom offers international transit services between Asia and Europe.

Source: Extracted from ESCAP, "Harnessing Cross-Sectoral Infrastructure Synergies", ICT and Disaster Risk Reduction Division Staff Working Paper, December, 2014. Available at https://www.unescap.org/resources/working-paper-harnessing-cross-sectoral-infrastructure-synergies.

Sectoral infrastructure owners can play the role of operator and caretaker of a telecom backbone network. As discussed in Section 4, one way of sharing is where the infrastructure provider and network provider roles are combined, and a sectoral player provides both passive and active infrastructures to telecom service providers. In Bhutan, for example, the operation and maintenance of the fibre-optic network are given to the Bhutan Power Corporation, for which the government pays them.[145]

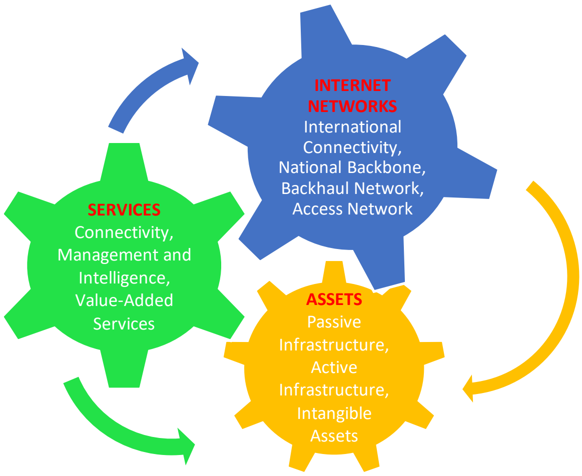
[145] For the installation of this fibre-optic cable system, the agreement between Bhutan Telecom Limited and Bhutan Power Corporation stated that Bhutan Power Corporation would receive maintenance and lease fees, as well as the right to access 12 of the 24 cables. To oversee the national fibre assets, two committees have been established – the Systems Coordination Committee and the Technical Coordination Committee. Source: ESCAP, "ICT Co-Deployment with the Electricity Infrastructure: The Case of Bhutan", Asia-Pacific Information Superhighway (AP-IS) Working Paper

It should be noted that the emerging NGN will be more complex, and the operations and maintenance of the network infrastructure will require more dedicated monitoring and provision of end-to-end solutions to telecom service providers.

5.4 Models of Infrastructure Asset Sharing

In the past, infrastructure sharing mainly focused on last-mile coverage, where regulated access was given to the backbone network to reach the end users. Such arrangements were limited to the ICT sector, more precisely to mobile operators. With the entry of different sectoral players having their own fibre-optic networks, new sharing models based on mutualization and cooperation came to the forefront.[146] The emerging trend is towards greater collaboration among the infrastructure owners to build a common telecom infrastructure. They join hands to build, operate and maintain the infrastructure and generate revenues through mutual understanding. The goal is to expand broadband coverage, reach unserved and underserved populations, and provide resilient ICT services that will sustain socioeconomic activities in a digital world.

Figure 13: Collaborators of an Internet ecosystem



Source: Jose Marino Garcia and Tim Kelly, “The economics and policy implications of infrastructure sharing and mutualisation in Africa”, Background Paper for the World Development Report, World Bank, November 2015. Available at https://thedocs.worldbank.org/en/doc/533261452529900341-0050022016/original/WDR16BPInfrastructureMutualisationGarcia.pdf.

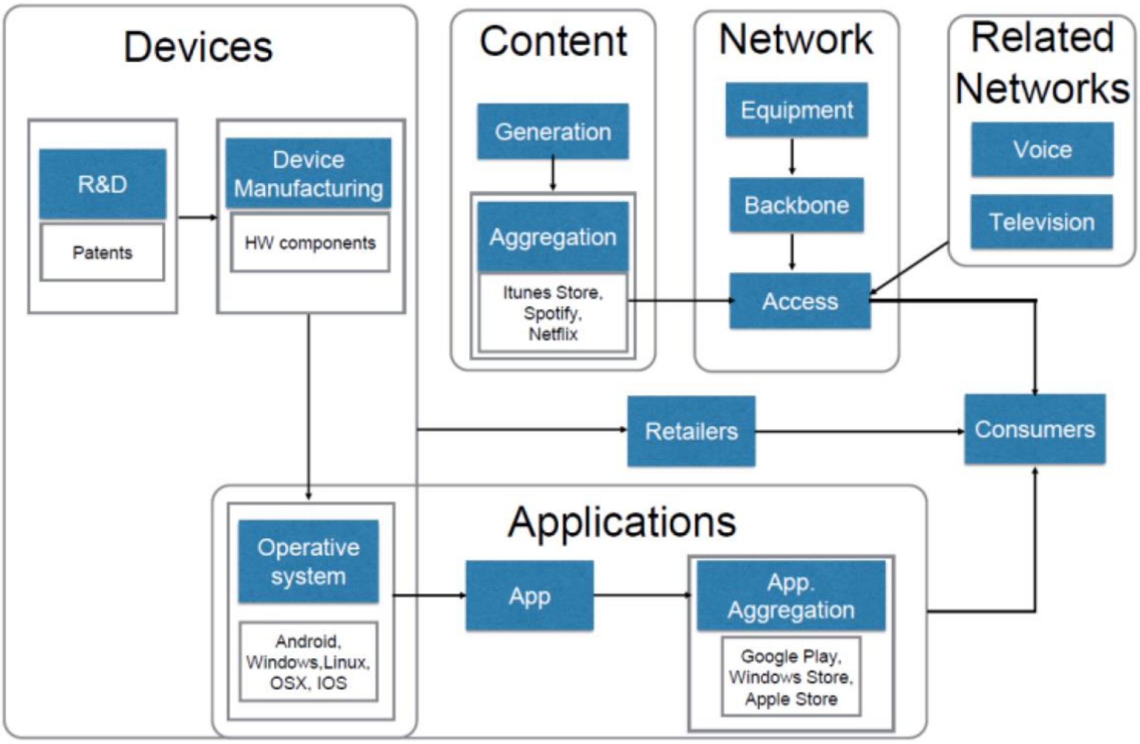
Series, June 2019. Available at https://www.unescap.org/resources/ict-co-deployment-electricity-infrastructure-case-bhutan.

[145] World Bank, “Cross-Sector Infrastructure Sharing Toolkit”. Available at https://ddtoolkits.worldbankgroup.org/infra-sharing.

[146] Jose Marino Garcia and Tim Kelly, “The economics and policy implications of infrastructure sharing and mutualisation in Africa”, Background Paper for the World Development Report, World Bank, November 2015. Available at https://thedocs.worldbank.org/en/doc/533261452529900341-0050022016/original/WDR16BPInfrastructureMutualisationGarcia.pdf.

Three major components operate simultaneously to sustain today's stable, resilient and accessible Internet ecosystem (Figure 13). These three components are the telecom networks, infrastructure assets and ICT services. While the networks ensure the connectivity between locations, cities, countries and continents, the infrastructure assets (both active and passive) are necessary to carry these networks between places. It also includes intangible assets like rights of way and telecom licences granted to an entity. Once these two components are aligned, ICT services can be offered to the end users (Box 10).

Box 10: Internet ecosystem



The Internet ecosystem is the assets, services and associated markets that interact with or use Internet telecom networks. OTT services and applications that use the Internet as a platform to provide content, email, search and cloud data storage are all elements of the Internet ecosystem. Network equipment and user terminals, manufacturing markets, operative system markets, content and application aggregation markets, spectrum markets and markets for other telecom services that can be bundled with retail Internet access, such as mobile and fixed voice communication services and cable television, are related markets in the ecosystem.

Source: Extracted from Jose Marino Garcia and Tim Kelly, "The economics and policy implications of infrastructure sharing and mutualisation in Africa", Background Paper for the World Development Report, World Bank, November 2015. Available at https://thedocs.worldbank.org/en/doc/533261452529900341-0050022016/original/WDR16BPInfrastructureMutualisationGarcia.pdf.

Different infrastructure sharing models may be adopted to expand broadband connectivity in a country where different sectoral entities may join hands through mutually acceptable arrangements backed by conducive regulatory frameworks. Three prominent models have emerged so far, which are prevalent today:

1. Infrastructure asset sharing
2. Infrastructure mutualization
3. Infrastructure cooperation

The first model of infrastructure asset sharing exists predominantly among the different entities operating in the same market and still share their infrastructure like masts, ducts, antennas, transmitters and rights of use. We have seen the understanding reached in this category between Bangladesh Railways and Grameenphone, and Bhutan Power Corporation and Bhutan Telecom Limited.

The second model of mutualization exists where a common infrastructure is built, maintained and managed by a provider. Other telecom service providers rent these facilities in a non-discriminatory manner. Many sectoral entities with their own telecom infrastructure have been licensed to offer their networks to others in India. Public-private partnership arrangements are used to create a common nationwide Internet backbone with commercial telecom service providers covering the last mile. In India's BharatNet nationwide broadband project, broadband connectivity is taken to the villages through a mutual venture among telecommunication, power grid and railways. Three major telecom service providers – Reliance Jio Infocomm, Bharti Airtel and Vodafone Idea – have reached out to state-run Bharat Broadband Network Limited to use the BharatNet infrastructure to provide a variety of services.[147]

Examples of public-private partnership arrangements include: (1) the cooperative model, where infrastructure and service providers jointly build and operate the infrastructure with government subsidy; (2) the equity model, where the government obtains equity in exchange for its contribution; (3) the concession model, where the government issues a public tender to select a private operator to build and operate the infrastructure; and (4) the management contract where the government issues a public tender to select a private operator to build, operate and commercialize the infrastructure.[148]

The third model of infrastructure sharing is the cooperation model, the most relevant strategy for different sectoral infrastructure asset owners to provide broadband connectivity. The sectoral entities like roadways, railways, waterways, gas pipelines, or power utilities build or host infrastructural facilities like common ducts, fibre networks, poles and other assets, which are later allowed for use by other sectoral players or telecom service providers in a non-discriminatory manner based on agreed rent. Here, different sectoral owners of telecom networks need to work towards a synergy so that the infrastructures are constructed, operated, maintained and used through cooperation.

[147] Aashish Aryan, "Private telecom firms look to cut capex, approach BBNL to lease 'dark fibre'", *The Indian Express*, 10 February 2020. Available at https://indianexpress.com/article/business/companies/private-telecom-firms-look-to-cut-capex-approach-bbnl-to-lease-dark-fibre-6259476/.

[148] Jose Marino Garcia and Tim Kelly, "The economics and policy implications of infrastructure sharing and mutualisation in Africa", Background Paper for the World Development Report, World Bank, November 2015. Available at https://thedocs.worldbank.org/en/doc/533261452529900341-0050022016/original/WDR16BPInfrastructureMutualisationGarcia.pdf.

Different approaches can be adopted to enter into partnership agreements for infrastructure sharing between sectoral entities. These approaches are not prescriptive or mutually exclusive; rather, depending on the market and regulatory environment, sectoral infrastructure owners can use them individually, sequentially, or through a judicious, negotiated and pragmatic mix of these approaches.[149] One approach is joint planning and construction where partners negotiate the future ownership, management, revenue sharing and maintenance of the shared infrastructure. Co-deployment of fibre along roadways, railways or any other utility infrastructure can be addressed through this approach. Here, the opportunities for technological compatibilities, cost-sharing projections and locational challenges can be addressed well in advance. But this approach will need planning and a shared futuristic vision of the telecom infrastructure and its use across sectors or partners. For instance, a modern highway system can only plan for leveraging IoT applications and intelligent traffic system if the roadway authorities involve telecom entities.

A second approach is the historical railways-telegraph partnership where a sectoral infrastructure owner hosts the telecom infrastructure created by another entity. Here, the host generates additional revenue and may share maintenance costs with the partners, and both benefit from the arrangements besides cost saving and faster deployment of telecom facilities. India's prototype smart city, Naya Raipur, has an underground utility corridor that will host other sectoral utilities like water supply, sewerage, telecommunication and electricity.[150]

It is interesting to note that citizens are increasingly calling for such shared infrastructure, as seen from a public interest litigation case file in the Supreme Court of India asking for direction from the highest court to the government to mandatorily provide common utility duct or corridors for all public utilities in the construction plan of highways and roadways to avoid duplication of civil works.[151] Infrastructure Victoria in Australia is promoting integrated infrastructure planning and recommends a strategy to enable "vehicle to infrastructure" seamless connectivity on the road to provide essential information on road conditions and traffic flows, among other strategies (Case Study 6).

A third approach is to share unused infrastructure capacity with the incumbent owners. Entities like railway operators (India, Bangladesh), power transmission companies (Bhutan, India) and gas companies (Bombay Gas) can offer the unused bandwidth of their installed fibre network to other sectors as well as telecom companies on short-term or long-term lease for extending broadband services. In India, public utility companies such as Bombay Gas Company Limited, Gas Authority of India Limited,

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[149] World Bank, "Cross-Sector Infrastructure Sharing Toolkit". Available at https://ddtoolkits.worldbankgroup.org/infra-sharing.

[150] Ryan Frantz, "What every Indian city can learn from Naya Raipur: India's first truly integrated city", *Your Story*, 31 May 2018. Available at https://yourstory.com/2018/05/naya-raipur-smart-city/amp.

[151] The Indian Express, "SC notice to Centre on plea for mandatory common utility duct along highways", 17 March 2021. Available at https://www.newindianexpress.com/nation/2021/mar/17/sc-notice-to-centre-on-plea-for-mandatory-common-utility-duct-along-highways-2277827.html.

Indian Railways and Power Grid Corporation of India Limited have been leasing their surplus fibre to telecom operators.[152]

Case Study 6: Integrated infrastructure planning in Victoria, Australia

The ICT infrastructure supporting businesses and households is regulated by the Australian government, and provided and managed predominantly by the private sector, except the National Broadband Network, a wholesale open access data network. Therefore, there is no requirement for the state government of Victoria to provide or fund the ICT infrastructure in urban areas. Instead, the state government plays a role in facilitating the provision of infrastructure that enables competition by the private sector, without resulting in oversupply or duplicate ICT infrastructure.

For instance, in areas where the streetscape is significantly redeveloped, conduits are provided that can be used by multiple providers at a future date to enable efficient provision of fibre. Government can facilitate the roll out of the conduit by developing a governance mechanism for access, operation and cost sharing of the infrastructure.

There is also an opportunity for government to support the development and adoption of smart technology such as dynamic street markings and signage, real-time monitoring of traffic and public transport vehicles, and communication with smart devices. Government can facilitate the roll out of infrastructure, such as smart light poles, by developing a governance mechanism for them to be provided and managed to enable competitive utilization by multiple organizations.

Source: Infrastructure Victoria, "Growing Together: The case for better integration of land use and infrastructure planning in established areas", December 2020. Available at https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/12/Growing-together-December-2020-1.pdf.
Photo credit: techAU

A fourth approach entails setting up a joint venture telecom company, in which an infrastructure owner collaborating with other sectoral players can use, upgrade and commercialize the existing infrastructure assets. A joint venture is where companies in the agreement form a joint venture to own and operate the networks, which means

[152] Indian Infrastructure, “Fibre Footprint: Need for high bandwidth drives OFC demand”, November 2018. Available at https://indianinfrastructure.com/2018/11/28/fibre-footprint/.

that the shared infrastructure is consolidated, owned and operated by the joint venture (but the companies do not directly own the infrastructure). Note that joint ventures can also operate as tower companies that own towers and lease them to mobile operators for use.[153] The partners support the joint venture to build, operate and maintain the network and lease it out to others for use. The partners need to agree on the financial arrangements based on their respective roles and contribution in setting up the network. Viom Networks is India's largest telecom infrastructure joint venture.[154]

A fifth approach is for the sectoral infrastructure owner to create a commercial telecom network and offer wholesale telecom services to other sectors. In this approach, the infrastructure is not shared per se but offers to share the benefits of the incumbent's infrastructure to other entities from different sectors. An example of this approach is Towngas Telecommunications in Hong Kong, China (Case Study 7). This approach is also being adopted in India. RailTel, one of India's largest telecom infrastructure companies set up by the Indian Railways in 2000, offers bulk telecom services focusing on broadband and virtual private network facilities. GAILTEL, set up by GAIL India (formerly known as Gas Authority of India Limited), maintains around 9,000 km of the fibre network installed along its gas pipelines. GAILTEL now leases fibre and other infrastructure facilities to telecom service providers, and its major customers include Vodafone Idea, Tata Communications and Lightstorm Telecom.[155] Similarly, Bharat Broadband Network Limited is set up by the Government of India under the Ministry of Communications and Information Technology, Department of Telecommunications for the establishment, management and operation of the National Optical Fibre Network.[156]

[153] GSMA, "Infrastructure Sharing: An Overview", 18 June 2019. Available at https://www.gsma.com/futurenetworks/wiki/infrastructure-sharing-an-overview/.
[154] Viom Networks. Available at http://viomnetworks.careersitemanager.com.
[155] GAIL (India) Limited, "GAILTEL". Available at https://gailonline.com/gailtel.html.
[156] Bharat Broadband Network Limited. Available at http://www.bbnl.nic.in.

Case Study 7: Towngas Telecommunications, Hong Kong, China

As a wholly-owned subsidiary of the Hong Kong and China Gas Company Limited, Towngas Telecommunications Company Limited is a carrier-neutral telecom service provider. With the advantage of the advanced glass-in-gas techniques from Europe, Towngas Telecommunications is known as a provider of high-end telecom infrastructure and quality network solutions in China and Hong Kong, China.

Towngas Telecommunications has been driving industry development by advocating innovative applications for the telecom and gas industries. Towngas Telecommunications' technical standards for laying fibre casing pipe in gas pipeline successfully obtained the approval from China Gas Association and lays a foundation for technical and applied research on safety monitoring of gas pipeline.

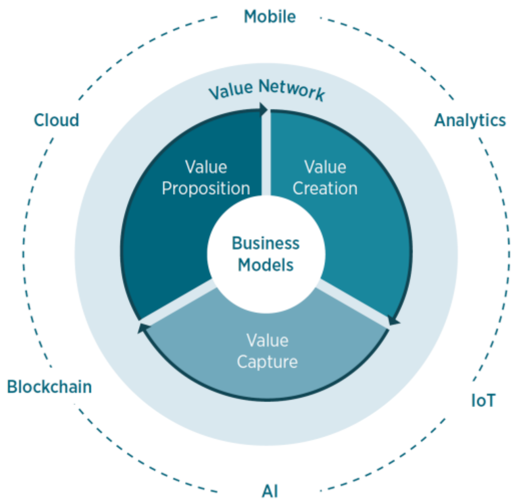
With the advent of big data and 5G, there is high demand for data processing, resulting in the establishment of seven data centres in China and Hong Kong, China that can accommodate up to 33,000 server racks.

Source: Towngas Telecommunications. Available at https://www.towngastelecom.com/.

5.5 Infrastructure Coopetition among the Utilities

Infrastructure sharing between different sectors will primarily depend on cooperation and collaboration among the partners, and a conducive regulatory environment. Despite a nudge from the regulators, the sharing agreements are often not reached by the parties due to operational, financial, industry structure, technological and institutional factors. Researchers have found the need to move from competition to coopetition for fruitful infrastructure sharing,[157] where cooperation and competition work simultaneously among rival parties (Box 11). Therefore, any prospective business models for infrastructure sharing should consider internal resources such as technology, capacity and business strategy, and the external environment such as customers, markets and business partners.[158] Business models can be seen as a strategy for developing a value network through an interaction between value proposition for the customer, value creation and value capture (Figure 14).

Figure 14: Value network in coopetition-based business model



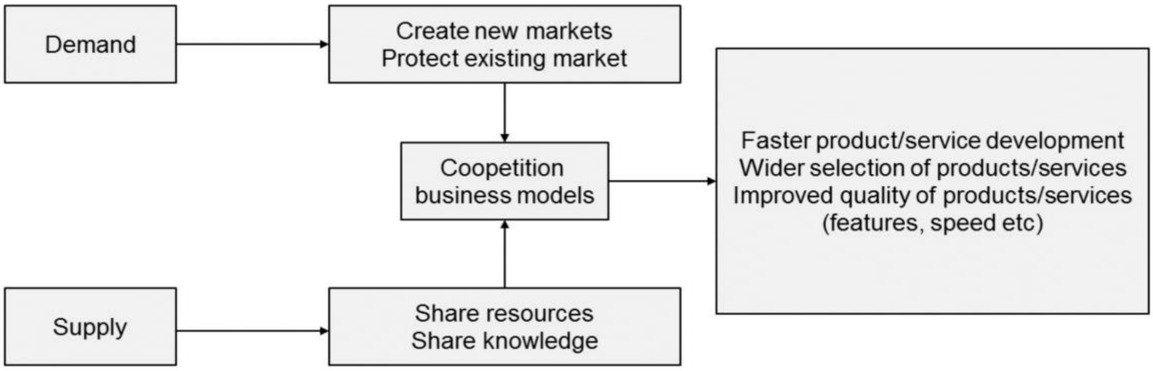
Source: Chandler Velu, "Coopetition and Business Models", Cambridge Service Alliance Working Paper, University of Cambridge, July 2018. Available at https://cambridgeservicealliance.eng.cam.ac.uk/system/files/documents/July2018Paper.pdf.

[157] Coopetition is the act of cooperation between competing companies; businesses that engage in both competition and cooperation are said to be in coopetition. Certain businesses gain an advantage by using a judicious mixture of cooperation with suppliers, customers and firms producing complementary or related products. Source: Adam Hayes, "Coopetition", *Investopedia*, 18 June 2021. Available at https://www.investopedia.com/terms/c/coopetition.asp. For details see John von Neumann and Oskar Morgenstern, *Theory of Games and Economic Behavior* (Princeton University Press, 1944).

[158] Chandler Velu, "Coopetition and Business Models", Cambridge Service Alliance Working Paper, University of Cambridge, July 2018. Available at https://cambridgeservicealliance.eng.cam.ac.uk/system/files/documents/July2018Paper.pdf. For details see Anne-Sophie Fernandez and others, eds., *The Routledge Companion to Coopetition Strategies* (Routledge, 2018).

The coopetition approach in the business model looks out for building a value network where competitors in a market work as partners to offer a value proposition to the customers through value creation and capture.[159]

Box 11: Coopetition approach



Studies have shown that firms are increasingly cooperating and competing at the same time to create competitive advantage and, hence, deliver superior returns. Shorter product lifecycle, convergence of multiple technologies and increasing cost of conducting research and development require firms to share resources with their competitors to improve the delivery of existing customer value proposition or develop new propositions. Resources needed to compete effectively often do not reside within a single firm and, hence, firms in the same competitive set often cooperate to share resources and then compete to divide the jointly created value. Such simultaneous collaborative and competitive activities have been termed coopetition.

Coopetition is increasingly becoming the approach that is adopted by competing firms to create competitive advantage. The reason for coopetition can be defensive or offensive, depending on the relative threats and opportunities. Often the basis for coopetition is to grow existing, or create new, markets, to share resources in fast-changing environments to achieve efficiency and enhance innovation capabilities. Coopetition requires the ability of firms to design, implement and manage new business models.

Source: Extracted from Chandler Velu, "Coopetition and Business Models", Cambridge Service Alliance Working Paper, University of Cambridge, July 2018. Available at https://cambridgeservicealliance.eng.cam.ac.uk/system/files/documents/July2018Paper.pdf.

To conclude, the demand for high-speed broadband is increasing every day. Therefore, there is a need to look beyond the traditional operators and telecom companies to build the necessary infrastructure and provide ICT services to the citizens. Sectoral players and utilities are seen as the new partners or stakeholders in this broadband mission to deploy fibre infrastructure of their own but share these

[159] Chander Velu, Golnar Pooya and Philip Dalzell-Payne, *Targeting the Full Value of Digital Disruption: Innovating business models for capturing value from new technologies* (Cambridge, University of Cambridge, n.d.). Available at https://www.ifm.eng.cam.ac.uk/insights/business-model-innovation/targeting-the-full-value-of-digital-disruption-through-business-model-innovation/.

whenever possible. Telecom regulators should encourage infrastructure sharing among the partners, emphasizing cooperation and mutual understanding and not necessarily compelling them by law. By diversifying their activities, generating additional revenue from sharing the fibre and other assets, and helping the nation create a robust Internet ecosystem, the sectoral utilities can contribute to the accelerated growth of the national economy. At the same time, the utilities themselves can leverage the networks to deliver better, and maintain and manage their services. Several countries have used the fibre networks built by sectoral utilities to support broadband connectivity (Figure 15).

Figure 15: Fibre network set-up by electricity utilities

	US	Ireland	Norway	Italy	New Zealand	Basel, Switzerland	Bavaria, Germany	Denmark
Utility	epb	ESB	36-utility partnership	enel	Northpower	iwb	SWM	14-utility partnership
Fiber Venture	EPB Fiber	SIRO	Altibox	Open Fiber	Northpower Fiber	IWB Net	M-Net	WAOO
Trigger for FTTx	■ Business diversifi-cation ■ Public funding	■ Market opportunity ■ National policy	■ Business diversifi-cation	■ National policy ■ Public funding	■ National policy ■ Public funding	■ National policy ■ Market opportunity	■ Business diversifi-cation	■ Business diversifi-cation
Business model	■ Retail	■ Wholesale	■ Retail	■ Wholesale	■ Wholesale	■ Wholesale ■ Retail (B2B)	■ Retail ■ Wholesale	■ Retail

Source: Arthur D. Little, "Utilities' Contribution to National Fiber Development: How Utilities and Telecom Operators Can Cooperate to Accelerate Fiber Deployment", July 2017. Available at http://www.adlittle.com/sites/default/files/viewpoints/adl_utilities_contribution_to_fiber_deployment.pdf.

Several utilities worldwide are helping the telecom sector roll out the broadband network and provide broadband access to citizens. The rising demand for high-speed Internet access, the leverage of the utilities to public funds and land rights, availability of a large amount of dark fibre and emergence of technology-mediated services management have all led to this environment of cooperation among the utilities and telecom operators.[160] Sectoral utilities are closer to the end user, and access to the household facilities (buildings, roads, pipelines) is more amenable to the users (Figure 16). Thus, cooperation among these sectoral players is by default a necessity in modern society.

[160] Arthur D. Little, "Utilities' Contribution to National Fiber Development: How Utilities and Telecom Operators Can Cooperate to Accelerate Fiber Deployment", July 2017. Available at http://www.adlittle.com/sites/default/files/viewpoints/adl_utilities_contribution_to_fiber_deployment.pdf
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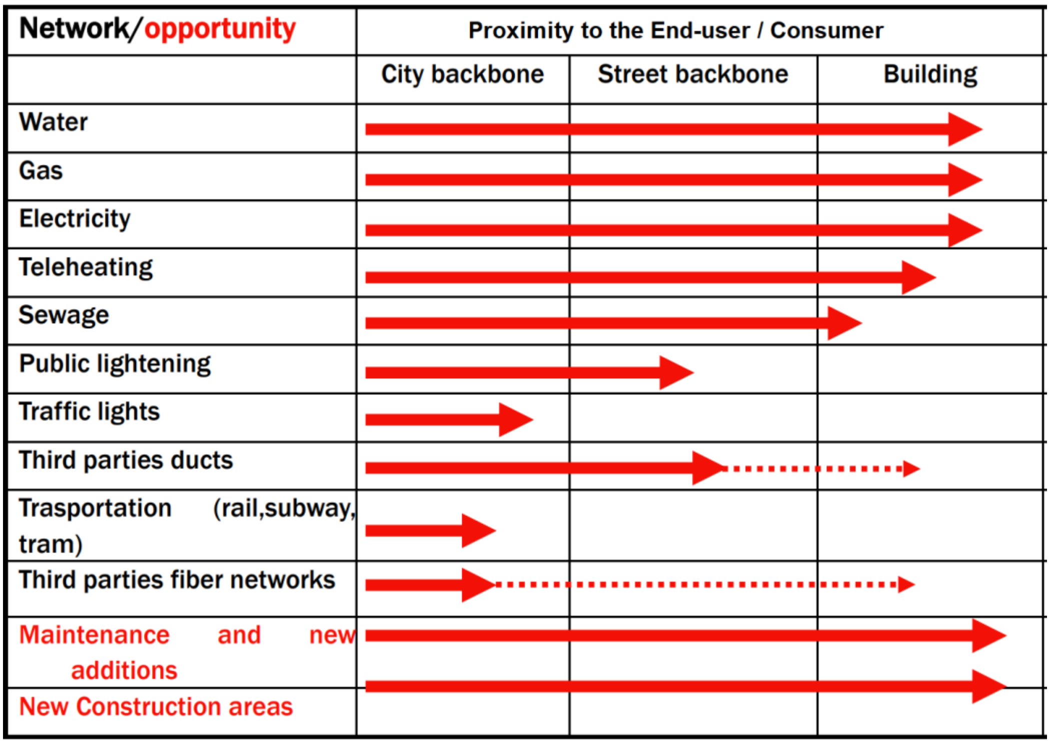
Figure 16: Proximity of utility networks to end users



Source: Lorenzo Pupillo, "Duct and Pole Sharing: An Operator's Perspective", presentation by Telecom Italia to the OECD Workshop on Fibre Investment and Policy Challenges, Stavanger, 10-11 April 2008.

The business cases for utilities vary, from utilities as wholesale operators partnering with telecom operators to deploy infrastructure (e.g., IWB and Swisscom in Switzerland), to state-created wholesale operators (e.g., Oman Broadband in Oman), to independent retail/wholesale operators (e.g., M-Net in Germany and Optilink/EPB in the United States). Historically speaking, fewer utilities have offered full retail operations. More have focused on providing wholesale services that generate healthy new revenue streams without the distraction of selling and marketing telecom services to end users.[161]

The way forward for the sectoral utilities, telecom operators and regulators is to create an environment of cooperation and mutual understanding for infrastructure sharing primarily based on negotiated partnership agreements on collaboration and revenue sharing arrangements rather than regulatory compulsions except perhaps in the cases of market failures.[162]

[161] Robert Baldwin, Colin Scott and Christopher Hood, eds., *A Reader on Regulation* (Oxford, Oxford University Press, 1998).
[162] Lorenzo Pupillo, "Duct and Pole Sharing: An Operator's Perspective", presentation by Telecom Italia to the OECD Workshop on Fibre Investment and Policy Challenges, Stavanger, 10-11 April 2008.

5.6 Summary

Infrastructure sharing requires the involvement of sectoral entities. Major roles that are played by the sectoral entities are that of: (1) carrier of the telecom infrastructure; (2) facilitator for expansion of national ICT infrastructure plans; (3) generator of additional revenue; and (4) operator and caretaker of a network (backbone).

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2. Infrastructure mutualization
3. Infrastructure cooperation

The first model of infrastructure asset sharing exists predominantly among the different entities operating in the same market and still share their infrastructure like masts, ducts, antennas, transmitters and rights of use. We have seen the understanding reached in this category between Bangladesh Railways and Grameenphone, and Bhutan Power Corporation and Bhutan Telecom Limited.

The second model of mutualization exists where a common infrastructure is built, maintained and managed by a provider. Other telecom service providers rent these facilities in a non-discriminatory manner. Public-private partnership arrangements are used to create a common nationwide Internet backbone with commercial telecom service providers covering the last mile. Public-private partnership agreements can be based on: cooperation, equity, concession or management contracts.

In the third model of cooperation, different sectoral infrastructure assets owners build or host infrastructural facilities like common ducts, fibre networks, poles and other assets that are later allowed for use by other sectoral players or telecom service providers in a non-discriminatory manner based on agreed rent. Here, different sectoral owners try to create a synergy so that the infrastructures are constructed, operated, maintained and used through cooperation.

In terms of infrastructure sharing arrangements, sectoral entities can adopt different approaches. One approach is joint planning and construction where partners negotiate the future ownership, management, revenue sharing and maintenance of the shared infrastructure. The second approach is a traditional one where a sectoral infrastructure owner hosts the telecom infrastructure created by another entity. The third approach is to share unused infrastructure capacity with the incumbent owners. The fourth approach is to set up a joint venture telecom company, in which an infrastructure owner collaborating with other sectoral players can use, upgrade and commercialize the existing infrastructure assets. The partners support the joint venture to build, operate and maintain the network and lease it out to others for use. Finally, the fifth approach is to create a commercial telecom network and offer wholesale telecom services to other sectors. In this model, the infrastructure is not shared per se but offers to share the benefits of the incumbent’s infrastructure to other entities from different sectors.

Infrastructure sharing between different sectors will primarily depend on cooperation, collaboration and a conducive regulatory environment. Researchers have found the need to move from competition to coopetition for fruitful infrastructure sharing, where cooperation and competition work simultaneously among rival parties. The coopetition approach in the business model looks out for building a value network where competitors in a market work as partners to offer a value proposition to the customers through value creation and capture.

The way forward for the sectoral utilities, telecom operators and regulators is to create an environment of cooperation and mutual understanding for infrastructure sharing primarily based on negotiated partnership agreements on collaboration and revenue sharing arrangements rather than regulatory compulsions, except perhaps in the cases of market failures.

5.7 Exercise: Check Your Progress

Answer the following:

1. While actors within the telecom sectors have long realized the benefits of infrastructure sharing, it is increasingly being accepted that there should be a much larger ______________ infrastructure sharing.
2. Public telecommunication needs the active support and ______________ of different infrastructure owners.
3. One of the major roles that are played by the sectoral entities is that of _______________ of the telecom infrastructure.
4. Through mutual sharing arrangements, a telecom operator is allowed to install its telecom networks on the ____________ legally owned by others.
5. It is important to reach consensus among the sectoral players that telecom facilities are a social _______________.
6. High-speed broadband connectivity is essential for all ________________ activities today.
7. Different sectoral entities are expected to play a larger role of ______________ in implementing a national broadband mission.
8. Sectoral entitles can also play the role of __________________ through infrastructure sharing.
9. In the past, infrastructure sharing was mainly focused on ___________ coverage where regulated access was given to the backbone network.
10. In the mutualization model, telecom service providers rent common infrastructure facilities in a ____________ manner.
11. Sectoral entities build or host infrastructural facilities and other assets in ________________ model of sharing.
12. A sectoral infrastructure owner may generate additional __________ by hosting infrastructure created by another entity.
13. The incumbent owners can share the existing unused capacity of infrastructure like ______ fibre.
14. The parties agree on the financial arrangements based on their respective roles and ____________ in setting up a joint venture network.
15. The way forward for the sectoral utilities, telecom operators and regulators is to create an environment of _______________________ understanding for infrastructure sharing.

5.8 Suggested Readings and Online Resources

1. Arthur D. Little (2017). Utilities' Contribution to National Fiber Development: How Utilities and Telecom Operators Can Cooperate to Accelerate Fiber Deployment. July. Available at http://www.adlittle.com/sites/default/files/viewpoints/adl_utilities_contribution_to_fiber_deployment.pdf.
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5. Velu, Chander, Golnar Pooya, and Philip Dalzell-Payne (n.d.). *Targeting the Full Value of Digital Disruption: Innovating business models for capturing value from new technologies*. Cambridge: University of Cambridge. Available at https://www.ifm.eng.cam.ac.uk/insights/business-model-innovation/targeting-the-full-value-of-digital-disruption-through-business-model-innovation/.
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APCICT

The Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT) was inaugurated on 16 June 2006 as a regional institute of Economic and Social Commission for Asia and the Pacific (ESCAP), and is located in Incheon, Republic of Korea. Guided by the 2030 Agenda for Sustainable Development and other internationally agreed development goals, the Centre's objective is to build and strengthen the capacity of members and associate members of ESCAP to leverage information and communication (ICT) for the purpose of socio-economic development. APCICT's work is focused on training, knowledge sharing, and multi-stakeholder dialogue and partnership.

APCICT is located in Incheon, Republic of Korea.

http://www.unapcict.org

ESCAP

The Economic and Social Commission for Asia and the Pacific (ESCAP) is the most inclusive intergovernmental platform in the Asia-Pacific region. The Commission promotes cooperation among its 53 member States and 9 associate members in pursuit of solutions to sustainable development challenges. ESCAP is one of the five regional commissions of the United Nations.

The ESCAP secretariat supports inclusive, resilient and sustainable development in the region by generating action-oriented knowledge, and by providing technical assistance and capacity-building services in support of national development objectives, regional agreements and the implementation of the 2030 Agenda for Sustainable Development.

https://www.unescap.org

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