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Accelerating Digital Infrastructure for Development

Background Note for the G20 Ministerial Declaration: A Digital Agenda for Development

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Abstract*

This document discusses ways in which sharing passive and active infrastructure within and/or across sectors can enhance quality and price-based digital services competition. Passive infrastructure sharing within the telecommunications sector and with other sectors such as transport, water, and energy enables faster digital infrastructure deployment and minimizes inefficient duplications. As sharing active and passive infrastructure enables savings—or revenues—and efficiencies for all participating infrastructure operators, such resources can be allocated to offer innovative and/or more affordable digital services.

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Sharing Infrastructure for Accelerating Development

Sharing passive and active layers of the digital infrastructure value chain unlocks resources for investing in innovation-based digital services competition. Given that in increasingly competitive digital infrastructure markets, market shares and revenues tend to be less concentrated, investment resources also tend to be more fragmented within a larger pool of stakeholders. Hence, not all stakeholders may have available the necessary resources, expertise, and willingness to invest and effectively compete in all the layers of the digital infrastructure value chain. Therefore, sharing digital infrastructure in several layers may enable certain stakeholders to effectively compete in those layers that are more critical for offering innovative digital services to final users, which has the potential of triggering bigger transformational development impact.

Passive and active infrastructure have very different operational and business models that may be suitable for different types of stakeholders. Digital infrastructure encompasses a wide variety of components ranging from brick and mortar to electronic equipment, which can be classified as passive or active according to their role and common characteristics. Thus, trenches, ducts, towers, masts, buildings, and dark fiber are examples of passive infrastructure, while routers, optical transmitters, antennae, Operations Support Systems (OSS), and Business Support Systems (BSS) are examples of active infrastructure. As these two types of infrastructure are very different in nature, they require different knowledge and skills to be operated, have different life-spans, and respond to different business models according to their different payback periods (e.g., 15 years for passive infrastructure versus 5 to 7 years for active infrastructure). Even though infrastructure costs depend on several parameters such as design, technology, materials, and terrain conditions, as a reference, when deploying broadband networks passive infrastructure accounts for 70 to 80 percent of total costs and the remaining 20 to 30 percent corresponds to active infrastructure (Broadband Commission, 2012).

Passive Infrastructure Sharing

Sharing passive infrastructure's excess capacity enables cost savings without hampering digital services differentiation-based competition. As the deployment of passive infrastructure has important economies of scale, they are often built with oversized capacity either to be kept for future usage or to be rented out by a specialized independent, competition-driven, or regulated operator. In particular, the latter case refers to passive infrastructure operators obliged by the national regulatory authority to comply with pro-competition obligations under certain circumstances such as abuse of dominant market power. In general, any scheme consisting of several operators' active digital infrastructure using shared passive infrastructure enables

significant cost savings over building redundant passive infrastructure, which in any case would not necessarily translate into valuable innovation-based digital service differentiation driving quality-based competition.

Passive infrastructure is the costliest layer, but it does not particularly enable digital services differentiation-based competition. Deploying passive infrastructure is considered expensive because it is labor intensive and requires large amounts of raw materials as well as very specialized and powerful machinery. Despite that the location and technical characteristics of passive infrastructure are key to offer good quality of digital services, given that they can be easily quasi-replicated by any competitors with sufficient financial resources and are mainly transparent to final users, often they are not considered as critical enablers of end-user service differentiation.

Because deploying passive infrastructure has important economies of scale, they are often built with oversized capacity. The cost of deploying digital infrastructure does not vary significantly with the capacity installed. For instance, the type, quantity, and cost of raw materials, tools, machines, and manpower needed for installing a 24-strand fiber-optic cable are pretty much the same as those for a 48-strand cable. Furthermore, the manufacturing of digital infrastructure components has economies of scale too: the relation between their capacity and cost does not grow linearly. Therefore, there are economic incentives to build digital infrastructure with oversized capacity, expecting either to use it in the future as demand grows or to rent it out to active digital infrastructure operators.

Passive infrastructure operators are increasingly specialized and independent from active infrastructure operators. Many digital infrastructure operators are vertically integrated and own and manage both passive and active assets, but they are managed by different technically and commercially specialized business units. As passive infrastructure is often built with capacity surpluses (e.g., telecommunications towers with space for more than one set of antennae, ducts and masts with space for more than one set of cables), its operators often decide—or may be obliged by public authorities—to rent out the remaining capacity to active digital infrastructure operators. Thus, with passive and active infrastructure managed by separate specialized business units, operators often decide—or may be obliged by public authorities—to separate the two into independent entities.

Passive infrastructure sharing within the telecommunications sector

Jointly designing and building new and tailored shared passive infrastructure may unlock funds for deploying separate innovative active infrastructure and enhance its performance. Given that

passive infrastructure typically has a longer life-span than active infrastructure, telecommunications operators periodically face the dilemma of replacing active infrastructure while leveraging existing passive infrastructure versus directly building new and tailored passive infrastructure to support new generations of active infrastructure technology. As the latter option requires higher capital investment in passive infrastructure but enables better performance of new active infrastructure, a joint design, buildout, operation, and maintenance of shared new and tailored passive infrastructure may be a suitable balance for many telecommunications operators willing to reduce investment in passive infrastructure while enhancing their active infrastructure performance to compete in quality of digital services offered to end users.

As different active infrastructure technologies require different network and passive infrastructure planning, leveraging legacy passive infrastructure may not enable the best performance of new active infrastructure. For instance, different mobile telephony and broadband technologies using different frequencies with different propagation characteristics require different site and network planning: technologies using lower frequencies (e.g., 4G antennae using the 700MHz band) in scarcely populated areas may need fewer but higher towers than technologies using higher frequencies (e.g., 5G antennae using the 6GHz or higher bands) in densely populated urban areas. Hence, for instance, when mobile broadband operators plan to migrate from 4G to 5G antennae, the existing scattered high telecommunication towers supporting 4G equipment operating in low frequencies and covering large geographic areas may not be the most suitable passive infrastructure—or at least may not suffice—to support new 5G antennae operating in high or extra-high frequencies that offer shorter coverage ranges. Thus, mobile broadband operators planning the 4G to 5G migration may have to complement the investment in innovative active infrastructure with the buildout of suitable passive infrastructure to maximize the performance of new 5G antennae.

Sharing the buildout, operation, and maintenance of passive infrastructure can save about 15 to 20 percent of total network deployment costs. Besides upgrading last-mile infrastructure to offer cutting-edge digital services, as data traffic growth is expected to continue accelerating, passive infrastructure operators may also need to upgrade backhaul and backbone networks, as well as interconnection and datacenter facilities, according to growing needs. Just by sharing a site, operators can save about 10 percent of total network deployment costs in capital expenditures such as site acquisition and preparation costs, and in operating expenses such as site rental, administration, and basic maintenance costs. Furthermore, sharing passive infrastructure can save an additional 5 to 10 percent of total network deployment costs in capital

expenditures such as power, security, climatization equipment, and infrastructure, and in operating expenses such as electricity consumption (Broadband Commission, 2014).

Passive infrastructure sharing across sectors

National and cross-border cross-sectoral infrastructure sharing can speed up digital infrastructure deployment, enabling savings and efficiencies. Operators of other sectors' infrastructure such as water and sanitation, oil and gas, electricity, road, and railroad deploy national and cross-border passive infrastructure that can be leveraged to deploy active infrastructure, thus saving financial resources and time and avoiding certain inconveniences. Moreover, these sectors' operators often deploy digital active infrastructure for corporate communications, as well as to monitor and operate their sector-specific infrastructure more efficiently. To illustrate this extent, high-voltage Optical Ground Wire (OPGW) cables, which are commonly used in electricity transmission lines, are built with a fiber-optic cable core surrounded by electricity conductor wires to serve a dual purpose. Furthermore, in the case of national and cross-border infrastructure for transport of passengers, it is expected that operators increasingly include digital connectivity active infrastructure to offer internet access services to passengers, while transport infrastructure in general will tend to increasingly incorporate digital connectivity infrastructure to reduce human intervention in daily operation of vehicles in areas such as intelligent transport systems and supply chain. Hence, both cross-sectoral passive and active infrastructure sharing may unlock important benefits for all participant sectors' stakeholders.

National and subnational authorities may unlock important savings and efficiencies by mapping passive infrastructure and harmonizing civil works permits to effectively implement "dig once" policies. Successfully implementing "dig once" policies—consisting of coordinating civil works related to infrastructure deployment across and within sectors—can save time and resources and minimize inconveniences and redundant infrastructure by laying out accessible ducts with substantial unused capacity and by synchronizing deployments. Nevertheless, public authorities need to play a critical role for successfully implementing such policies, because operators require precise and georeferenced information of existing and planned infrastructure to be able to synchronize civil works and infrastructure deployments and, given the competitive nature of stakeholders and the variety of sectors, a public authority can play a critical role in centralizing information and coordinating communications. Moreover, for operators to be able to synchronize civil works and infrastructure deployment the required permits should be processed and issued in a timely manner, and national and subnational authorities can play a key role also in harmonizing the conditions and streamlining the processes for obtaining them.

Leveraging existing transport and energy cross-border infrastructure may speed up cross-border digital infrastructure deployment and reduce certain costs. As terrestrial telecommunications infrastructure was traditionally conceived by national operators offering services within the national territory, neighbor countries' national networks often reach communities close to the border, but don't reach the border itself. Moreover, geographic elements such as rivers and mountains that hinder pedestrian transit and historically influenced the definition of many borders also hindered the deployment of several sectors' infrastructure. However, in recent centuries international trade of merchandise and supplies has been a powerful driver of transport and energy cross-border infrastructure deployment. Telecommunications infrastructure can leverage existing infrastructure such as oil and gas pipelines, electricity transmission lines, roads, and railroads to deploy cross-border fiber-optic networks with considerably less investment in civil works, installation of masts and ducts, rights of way, land-use rights, and bilateral political and administrative agreements. Of course, the rollout of fiber-optic networks still has a relevant cost, and important coordination efforts for governing and operating cross-border telecommunications networks would still be necessary, but digital infrastructure operators can benefit from the progress achieved by other sectors' operators in previous infrastructure deployments while providing them with an additional revenue stream.

An example of accomplishment in cross-sectoral cross-border infrastructure sharing is the Central American Telecommunications Network (REDCA per its acronym in Spanish), which leverages the Central American Countries' Electrical Interconnection System (SIEPAC per its acronym in Spanish). The fiber-optic cables of REDCA are laid out on SIEPAC's passive infrastructure that is owned by national electricity transmission companies from six Central American countries—Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama—which are members of REDCA's Executive Board.[1]

Active Infrastructure Sharing

Telecommunications operators, equipment manufacturers, and national regulatory authorities reach agreements, develop technology standards, and issue regulations to promote active

[1] REDCA's Executive Board members are representatives of the national electricity transmission companies of the six countries covered by the network—the Costa Rican Electricity Institute (ICE per its acronym in Spanish, from Costa Rica), the Lempa River Hydroelectrical Executive Commission (CEL per its acronym in Spanish, from El Salvador), the National Electrification Institute (INDE per its acronym in Spanish, from Guatemala), the National Electrical Energy Company (ENEE per its acronym in Spanish, from Honduras), the National Electricity Transmission Company (ENATREL per its acronym in Spanish, from Nicaragua), and the Panamanian Electricity Transmission Company (ETESA per its acronym in Spanish, from Panama)—plus representatives of three other electricity transmission companies: the Federal Electricity Commission (CFE per its acronym in Spanish, from Mexico), the National Electrical Energy Entity (ENEL per its acronym in Italian, from Italy), and InterNexa (from Colombia). Additional information is available at http://www.redcasiepac.com.

infrastructure sharing. Telecommunications operators' active and passive infrastructure costs increase continuously to be able to compete in innovative services offering higher data traffic velocity, while telecommunications services revenues don't follow the same growth trend because they are driven by price competition. Hence, private stakeholders at different levels of the telecommunications market value chain adopt active infrastructure-sharing measures to improve the revenue-cost ratio, while public authorities encourage and/or oblige operators to share active infrastructure to promote competition in digital services to end users. Other digital infrastructure stakeholders such as datacenter operators follow similar trends because they increasingly share servers' memory and computing power to run cloud computing services on virtual machines.

National roaming enables a mobile telecommunications operator with limited active infrastructure to offer commercial services using other operators' antennae. Often, other operators' active infrastructure is used either because the operators cover different geographic areas and agree or are obliged to reciprocally allow the other one to offer services using their active infrastructure, or because the national regulatory authority obliges an existing operator to allow an entrant operator to offer services using an existing operator's active infrastructure for a regulated period of time and price while the entrant develops its own infrastructure (Inter-American Development Bank, 2017).

The mobile telecommunications electronic equipment industry develops new technologies incorporating active infrastructure sharing by design to reduce deployment costs. Traditionally, the main stakeholders of the telecommunications electronic equipment industry used to develop new technologies aiming at deploying and commercializing them with limited cooperation with other stakeholders in order to maximize the return on investment in technology innovation development. However, since the development of LTE (Long Term Evolution) technologies, expected revenues did not seem to be able to keep pace with the expected surge in data traffic and its related infrastructure costs; hence, the business case for sharing active infrastructure became strong enough for stakeholders to consider incorporating sharing mechanisms during the standard inception phase of LTE technology (Alcatel-Lucent, 2010).

Sharing Other Scarce Resources

Rights of access and use

Ensuring smooth shared access and use of land and facilities may be a critical success factor for sustainable infrastructure-sharing schemes. Deploying, operating, and maintaining digital infrastructure may require accessing and using public or private land and facilities such as end users' houses, roofs, ducts, subway tunnels, ways to access mobile telecommunications sites,

mobile telecommunications towers, datacenters, interconnection points, Internet Exchange Points, satellite stations, submarine cable landing stations' dry plants, manholes, etc. Regardless of who owns the land and/or facilities, all operators need to have the right to access and use it per the sharing agreement's conditions and clauses, which should be designed according to all participating stakeholders' needs. Given that land and facilities hosting critical active infrastructure may have restricted access enforced by security measures, smoothly coordinated access permission mechanisms—both for planned access and use and for emergency situations—are critical for ensuring sustainable, satisfactory, and efficient implementation of an infrastructure-sharing scheme.

Shared use of rights-of-way is one of the most common agreements in cross-sectoral infrastructure-sharing schemes. Since the deployment of the first telegraph lines, traditionally telecommunications networks have been deployed along other sectors' lineal infrastructure such as railroads, roads, electricity lines, and more recently water and oil and gas pipelines, because even when the telecommunications network does not use the other lineal physical infrastructure, it is able to leverage its right-of-way, allowing access and use of the land over which the infrastructure was built. While infrastructure-sharing schemes among telecommunications operators may be overseen, facilitated, and even enforced by the telecommunications sector's national regulatory authority, cross-sectoral infrastructure-sharing schemes may benefit from either several public authorities' coordination across sectors or from an overarching cross-sectoral authority in charge of ensuring that all parties comply with the terms and conditions of their sharing agreement.

Spectrum rights of use

Flexible spectrum licenses enable maximizing the optimization of use of this resource by sharing it among several stakeholders. Given the scarcity of radioelectric spectrum and its key role in wireless communications, both the industry and national and international spectrum-related institutions are exploring ways to maximize the use of this resource. Traditionally, spectrum rights of use were granted in technology-specific long-term licenses, which became an important constraint when, due to increasingly rapid technology evolution, the lifetime of a specific technology was shorter than the license's time frame and valuable spectrum bands risked remaining underused for several years while reserved for an obsolete technology. New spectrum management techniques overcome this limitation by enabling several wireless communications operators to share the right to use a spectrum frequency in specific time slots and geographic areas, hence maximizing its optimal usage.

One of the schemes explored consists of allowing spectrum license-holders to commercialize this asset in non-real-time spectrum secondary markets. The reforms required to implement non-real-time spectrum secondary markets are mainly of legal, regulatory, and administrative nature because they entail partially liberalizing the spectrum market.

Another scheme explored consists of real-time secondary markets, which besides legal, regulatory, and administrative reforms, require a real-time technology-enabled online spectrum marketplace. The rationale behind the latter approach is that wireless communications operators' spectrum demand is not constant—it varies by place and in time-—so operators needing additional spectrum to handle additional data traffic in a specific place and time would welcome having the option of paying temporary spectrum rights of use to a license-holder.

Finally, a simpler scheme explored consists of allowing a second wireless communications operator to use licensed spectrum that is consistently unused by the license-holder in a specific geographic area. As this last option would not require a real-time marketplace, the necessary reforms would be again mainly of legal, regulatory, and administrative nature.

Recommendations for Public Authorities

Passive Infrastructure Sharing within the Telecommunications Sector

Passive infrastructure sharing obligations imposed and enforced by national regulatory authorities on operators who abuse their significant market power may level the market's playing field. Telecommunications national regulatory authorities systematically conducting market definition and analysis to identify such operators may enhance market competition at several levels of the telecommunications sector value chain so that all operators can compete in fair conditions, which ultimately should benefit the quality and/or price offered to end users.

Passive Infrastructure Sharing across Sectors

Public authorities centralizing georeferenced information of existing and planned infrastructure and making detailed maps available to interested stakeholders may facilitate the sharing of passive infrastructure. Coordinating the collection of georeferenced information and keeping an up-to-date centralized database or a synchronized distributed database of the main infrastructure sectors' existing and planned infrastructure can enable significant savings in costs, time, and inconveniences related to civil works.

Active Infrastructure Sharing

Telecommunications national regulatory authorities drafting, conducting public consultation, and issuing guidelines for voluntary adoption of national roaming, as well as imposing it as an obligation on operators abusing significant market power, would level the market's playing field for new entrants and/or for existing operators willing to expand their market scope.

Sharing Rights of Access and Use

Drafting, conducting public consultation, and issuing guidelines on sharing rights of access and use can significantly facilitate the sharing of passive infrastructure among different sectors' stakeholders. One of the main challenges for fostering shared rights of access and use is that it often entails close coordination among different sectors' stakeholders, but often there is limited coordination among sectoral public institutions and/or there is no institution with a clear mandate to lead such coordination. Hence, even if sectoral institutions only managed to coordinate for the sole purpose of drafting, conducting a cross-sectoral public consultation, and issuing guidelines on sharing rights of access and use, such guidelines would lay the foundation for valuable voluntary cross-sectoral cooperation that could speed up the layout of digital infrastructure at a significantly lower cost.

Sharing Spectrum Rights of Use

Promoting technology-neutral spectrum licensing regimes and secondary marketplaces can significantly contribute to maximizing the efficient use of radioelectric spectrum. International institutions issuing spectrum recommendations and national spectrum management authorities designing and implementing spectrum management schemes and policies may enhance an optimal use of this scarce resource by, respectively, endorsing and adopting technology-neutral licenses and non-real-time and real-time secondary marketplaces.

Conclusions

Sharing passive and active infrastructure within and/or across sectors can enhance quality and price-based digital services competition. Passive infrastructure sharing within the telecommunications sector and with other sectors such as transport, water, and energy enables faster digital infrastructure deployment and minimizes inefficient duplications. As sharing active and passive infrastructure enables savings—or revenues—and efficiencies for all participating infrastructure operators, such resources can be allocated to offer innovative and/or more affordable digital services.

Passive Infrastructure Sharing within the Telecommunications Sector

Voluntary and/or obliged sharing of the buildout, operation, and maintenance of new and tailored passive infrastructure may enable telecommunications operators to unlock funds to focus their investments in innovative active infrastructure that enhances quality-based digital services competition. In certain cases, such as abuse of dominant market power, national regulatory authorities may impose passive infrastructure sharing obligations on a specific operator to level the playing field for all market stakeholders and thus enhance competition at several levels of the digital infrastructure value chain.

Passive Infrastructure Sharing across Sectors

Public authorities may play a key role in facilitating passive infrastructure sharing efforts between different sectors' stakeholders. National and subnational public authorities can pave the way for passive infrastructure sharing by centralizing and coordinating existing and planned infrastructure maps and georeferenced information, harmonizing civil works and related permits countrywide, and issuing passive infrastructure sharing guidelines.

Active Infrastructure Sharing

Active infrastructure sharing initiatives are associated with increasing telecommunications market quality and price-based competition. While certain national regulatory authorities encourage and/or require national roaming, telecommunications industry stakeholders reach agreements to develop innovative technologies that incorporate active infrastructure sharing standards by design, and operators deploy shared active infrastructure to focus their resources and efforts in competing in digital services.

Sharing Rights of Access and Use

Sharing rights of access and use of land and facilities within and across sectors may speed up infrastructure deployment and minimize investment and inconveniences. Rights-of-way held by passive infrastructure operators owning lineal energy and transport infrastructure are valuable assets commonly shared with telecommunications infrastructure operators to roll out fiber-optic networks. In order to expand this successful synergy and share other rights of access and use—such as those of facilities—comprehensive coordination mechanisms between operators must be thoughtfully designed and implemented to ensure that all operators can access and use the facility as agreed to effectively operate and maintain the infrastructure as required.

Sharing Spectrum Rights of Use

Licensing technology-neutral spectrum rights of use to allow for trade in non-real-time and real-time marketplaces may foster maximization of spectrum use. Several schemes could improve the flexibility of traditionally rigid spectrum management frameworks, including real-time and non-real-time and limited and unlimited place and time trading of spectrum rights of use.

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