Next Generation Access Networks: Infrastructure Sharing

João Paulo Pereira[1,3(✉)] and Isabel Maria Lopes[1,2,3]

[1] UNIAG (Applied Management Research Unit), Bragança, Portugal
{jprp,isalopes}@ipb.pt
[2] Centro ALGORITMI, Polytechnic Institute of Bragança, Bragança, Portugal
[3] School of Technology and Management, Polytechnic Institute of Bragança, Bragança, Portugal

Abstract. The migration to Next Generation Access Networks (NGAN) has raised a range of issues related to building wiring and infrastructure sharing. The deployment strategies for operators and entrants are completely different. European Commission argues that infrastructure-based competition is the best and fastest way for broadband development. The arguments are that infrastructure based competition provides efficiency incentives to operators, reduces prices, increase penetration, stimulates innovation, etc. However, civil costs represent up to 80% of the total roll-out cost of NGA. The study deployed shows several broadband access infrastructure sharing solutions.

Keywords: NGA infrastructure · Broadband access networks · Infrastructure sharing

1 Introduction

The Europe 2020 strategy focus the sustainable and social inclusive economic growth. The Digital Agenda for Europe proposes fast Broadband coverage: at least 30 Mbps for 100% of EU citizens (by 2020) and 50% of EU households with subscriptions above 100 Mbps (by 2020). To achieve this objectives, the strategy is the roll out of Next Generation Access (NGA) networks (e.g. Fiber to the home FTTH networks).

European commission new directive focus on facilitate NGN roll-out by reducing deployment cost. Civil Works and Physical infrastructure, deployment of high-speed broadband networks, and by any provider of public communications networks leads to the reduction of costs by 20 to 30% and exploit synergies with utilities (energy, water, transport) [1, 2].

In this context, it is important "obliged" all the entities to give access to its own (or managed) infrastructure suitable for accommodating European Competition Network (ECNs) (Fig. 1).

The access network is usually the most expensive component in terms of capital investment (specifically passive infrastructure) and OA&M costs. Of the several costs, civil engineering costs are greatest when it is necessary to run a new fiber or copper connection to the cabinet, building, or home. Moreover, access to existing infrastructure, such as the ducts of the incumbent or other market players or sewage pipes, is critically

Á. Rocha et al. (eds.), *Recent Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 571, DOI 10.1007/978-3-319-56541-5_25

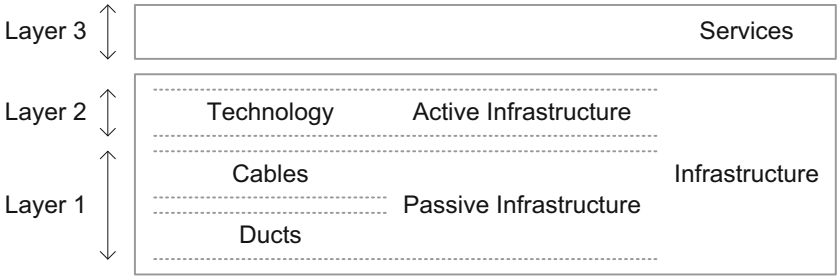

Fig. 1. Network layers [3].

important to avoid digging. For [3], a local loop network can be divided into three main layers or segments: a service layer and two infrastructure layers (see next figure). Layer 1 includes passive infrastructures, such ducts and cables, and requires the greatest investment. Layer 2 consists of active infrastructures, such as the technical installations at the end of the fibers that send, receive, and manage the optical signals. Layer 3 includes several services that consumers buy from telecommunication operators.

Andersen Management International [4] defends that an effective and sustainable infrastructure competition is superior to service competition, as it allows for head-to-head competition between operators and requires a minimal need for regulatory intervention with competitors not being reliant on the incumbent infrastructure. So, operators, especially new entrants, will have a choice as to whether they should invest in their own infrastructure (i.e. build) in order to provide services to end-users, or to seek access (buy) from an existing provider (normally the incumbent).

1.1 Infrastructure Sharing

The civil work required to deploy Next Generation Access (NGA) infrastructure is a significant part of the business case of any NGA deployment (ducts are not easily replicable), and some estimates put it as high as 80% of the overall cost [1, 5–7]. The broadband deployment cost reduction's directive (Directive 2014/61/CE) has four main pillars: Access to infrastructure, coordination of civil works, streamlining permit granting, and in-building infrastructure.

One of the solutions is provide access to exiting ducts, poles, antennas, etc. (see Fig. 2), that may lower barriers to entry and therefore support competition. However, to duct access became a viable option in the access network, it may need to be complemented by extra civil work to increase infrastructure capacity, the use of dark fiber (where available) or the use of conduits of alternative infrastructure providers.

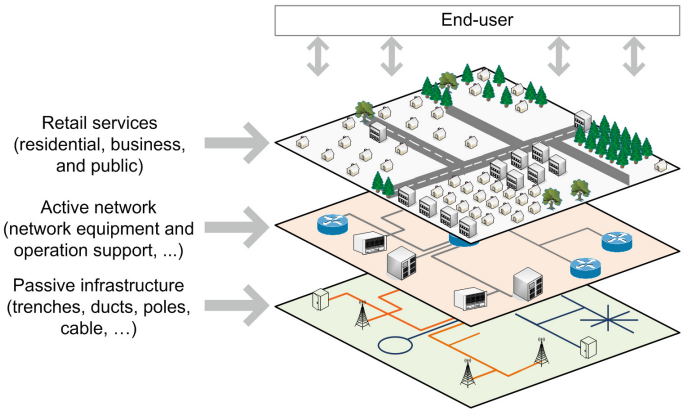

Fig. 2. Infrastructure sharing layers [7, 8].

1.1.1 Fixed Infrastructure Sharing

Overall, migration to fiber-based NGAN greatly complicates pro-competitive regulation due to both physical characteristics of the new (fiber-based) networks and the economic characteristics of the costs of deployment and, in turn, of business plans.

With regard to the key challenges of the migration to NGA for future competition and regulatory policy, it is reasonable to utilize a functional perspective and differentiate between the (1) passive infrastructure of trenches, ducts, and dark fiber, (2) active infrastructure, including lit fiber, and (3) actual service provision of retail services (see Fig. 2).

A priori business models that differ in the level of integration of these functions are possible. The challenge for competition and for competition policy will be to implement suitable forms of "open" access. The important issues related to competition for FTTC/VDSL and FTTB/H solutions are described in Table 1.

Table 1. Regulated wholesale services for VDSL and FTTH solutions [9].

FTTC/VDSL solution	FTTB/H solutions
• Unbundling of the sub-loop (network part between the street cabinet and the end user's home), • Access to or joint utilization of the cabinet, collocation at the cabinet, • Access to civil engineering infrastructure (e.g. "ducts"), • Access to the fiber access infrastructure between the newly established Metro Core Locations and the cabinets.	• Access to existing ducts - loop access to civil engineering infrastructure, • Joint establishment of trenches, ducts etc., • Access to the unbundled (dark) fiber loop, • Joint utilization of optical switching facilities (e.g. ODF), • Access to different colors in the case of WDM • Access to/joint utilization of in-house cabling.

[10] argued that service-level competition could exist over a shared FTTP network infrastructure. He added that sharing was possible at different levels and that the sharing of dark fiber required attention to the fiber layout (see Table 2).

Table 2. Sharing network infrastructure [10].

Layer	Shared infrastructure
0	Conduit and collocation facilities.
1 (Physical layer unbundling)	Dark fiber leasing, or perhaps, Optical Layer unbundling (CWDM or DWDM in PONs)
2 (Data link layer unbundling)	Dark fiber and link-layer electronics at each end. For example, Ethernet-based VLAN, or ATM-based PVCs.
3 (Network layer unbundling)	Basic network service provided. For example, IP Layer 3 service over cable using policy-based routing to multiple ISPs.

In layer 0, the owner of the trench/duct, can rent this part of the infrastructure to other operators, and receives an agreed fee from their use. The owner can (or not) also provide broadband services directly to subscribers. In layer 1, the owner (for example, incumbent operator) install for example optical dark fiber and the new operators rent the infrastructure (is required light the optical fiber). It is the customer's responsibility to install active optical equipment to light the fiber and maintain the network services [11]. To share layer 2, the infrastructure owner needs to light the optical fiber (requires active equipment), and customers are able to buy wavelengths. The service layer (layer 3) provides the capacity of network services provision (i.e., VPN, Internet, etc.).

In fixed solutions, infrastructure sharing can reduce costs because the duct is one of the most expensive components in the deployment of an NGAN. Results of studies and deployments suggest that civil infrastructure represents a large proportion of the costs of fixed access deployment. Further, they indicate that duct access or duct sharing can reduce or eliminate this capital cost and barrier to entry and may enable sustainable infrastructure-based competition in NGA [12, 13]. In the nonexistence of fiber unbundling, shared access to infrastructure ("duct access") presents a potential alternative passive remedy and provides the freedom for new entrants/competitors to innovate in their network whilst avoiding the high civil costs associated with new build. The survey performed by [5], show that overall, significant unoccupied space in the duct infrastructure was found (the overall average space in the duct-ends was 35%). Also, the results show that 51% of all duct-ends surveyed have at least 42% of unoccupied space, and that the distribution of the unoccupied space varies according to the cities/towns and sections of the network considered (more space is unoccupied in sections near the metro node, and less space is unoccupied in sections near the street cabinet).

In Portugal, the reference offer for access to ducts and associated infrastructure (known as duct access reference offer - ORAC) became, in February 2010, a regulatory obligation imposed on that operator following the finding of significant market power in the market for physical network infrastructure access. In 2008 and 2009 the government adopted measures to promote investment in NGA, focusing on access to horizontal and vertical infrastructures. The obligation of providing access to optic fiber has not yet been set out in detail. In October 2010, ICP-ANACOM (regulator) approved amendments to ORAC, in particular regarding information about duct occupation in competitive areas, conditions for accessing poles and conditions for compensation [14, 15]. Table 3 presents the duct access pricing in various countries.

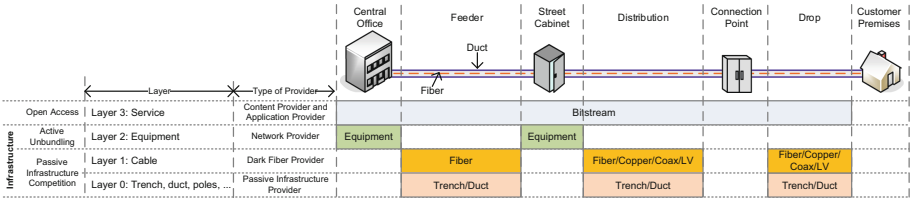

Fig. 3. Infrastructure sharing options (fixed solution).

Table 3. Duct access pricing [12].

Country	Pricing
Portugal	€7.50 - €10.60/month/km/cm2 Monthly charge for occupying sub-conduit (30 mm or 42 mm): Lisbon/Porto: €10.60/month/km/cm2 and Other municipalities: €8.30/month/km/cm2 Monthly charge for occupying a main conduit: Lisbon/Porto: €9.80/month/km/cm2 and Other municipalities: €7.50/month/km/cm2 Occupancy fees for associated infrastructure: Entry point in a footway box/manhole: €1.80/month Joint in a footway box/manhole: €3.90/month Spare cable in a footway box/manhole: €2.70/month
France	The pricing is calculated in relation to the amount of duct area that is occupied by the cable. The effective area is calculated by multiplying the cross-sectional area of the cable by 1.6. The draft price for duct access is €1.20/m/cm2.
USA	Duct: $0.50-$5.00/m/year and Pole: $5-20/year
Canada	Duct: CAN$27.00/30 m/year and Pole: CAN$9.60/year
Australia	AU$6.95/m/year

Under EC telecommunications rules, national regulators assessing an operator to have SMP in markets such as LLU (or access to the local loop) and wholesale broadband access (or bitstream access) must impose appropriate ex ante regulatory obligations [16]. LLU and wholesale broadband access allows alternative operators to enter the retail market and to offer broadband services to consumers. However, if in a particular market no operator has SMP, the regulator must define the regulatory remedies that should be imposed in order to address potential order to address potential anticompetitive behavior, prevent abuse of SMP and/or promote competition.

Several OECD countries are applying geographically disaggregated regulation. In 2007, Ofcom (United Kingdom regulator) was the first regulator in the EU to define sub-national geographic markets for wholesale broadband access and found that the incumbent did not have SMP in one of the defined local markets. Ofcom define sub-national markets and a relaxation of ex ante regulation in the most competitive areas of these markets (densely populated Central and East London Area). [17] identify four sub-national geographically segmented markets: Hull, local exchanges where Kingston Communications is the only operator (0.7% of UK premises); Market 1, local exchange

areas where only British Telecom is present (16.4% of UK premises); Market 2 - local exchange areas with 2 or 3 wholesale providers and forecasts for 4 or more, but where the exchange serves less than 10,000 premises (13.7% of U.K. premises); and Market 3 - local exchange areas with 4 or more wholesale providers and forecasts for 4 or more, but where the exchange serves more than 10 000 premises (69.2% of UK premises). For example, in Market 3, the regulator considers that there is effective competition to protect consumer interests and that regulatory obligations should be withdrawn from this market (after a transition period of one year).

In Australia, the regulatory authority (ACCC) argues that it is important that the LLU is a declared service available on a regulated basis, and for which the ACCC has signaled cost-based prices on a geographically de-averaged basis - Australia has different ULL prices for different regions with distinct pricing areas [18–20]. The Australian incumbent operator (Telstra) also defends that in several urban areas there is significant and increasing competition in access infrastructure that these areas should not be subject to ex ante regulation [21].

The Canadian NRA (CRTC) defends that facility is considered vital if it satisfies all three of the following conditions: (1) The facility is required by competitors as an input for provision of telecommunications services in a relevant downstream market; (2) The facility is controlled by a firm that possesses upstream market power such that withdrawing mandated access to the facility would likely result in a substantial lessening or prevention of competition in the relevant downstream market; and (3) It is not practical or feasible for competitors to duplicate the functionality of the facility. When services don't satisfy all three conditions or fit within the other regulatory categories should not be subject to ex ante regulation. Generally, CRTC apply wholesale regulation on the national basis and retail regulation is segmented geographically.

The study of [13] show that duct access can work relatively easily for new build, and can also work for brownfield NGA projects with case examples identified in Italy (Telecom Italia Socrate duct offering), Australia (Telstra duct offering) and in Japan (NTT obligatory and general passive infrastructure offering). The study also demonstrate that duct access is more likely to be successful for NGN and NGA where the final duct section is not required to be shared (e.g. FTTC). [22] defends the sharing of passive infrastructures (ducts, trenching,…) will be an important key.

1.1.2 Mobile Infrastructure Sharing

As the main driver to share networks is reducing network costs, that represents one-third of total expenditure, network sharing between the mobile operators in the European countries has grown in importance. For example, in UK operators have announced their intention to share some elements of their access networks [17]. The most common shared options used in mobile solutions are mast (also known as pylon or tower) sharing and co-location. Figure 3 presents the infrastructure sharing options (Fig. 4).

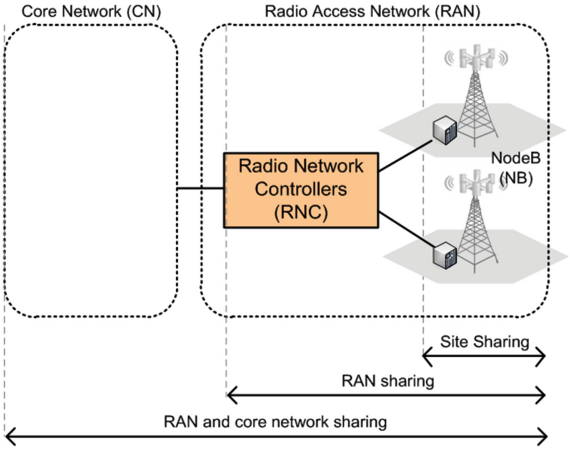

Fig. 4. Infrastructure sharing options (mobile solution).

Infrastructure sharing between multiple operators can be implemented in several ways [23]: (1) Physical infrastructure (e.g., masts and antenna systems) has been shared frequently in second-generation systems; and (2) Sharing the complete RAN and part of the core network has recently been implemented in some countries during the introduction of 3G networks (Table 4).

Table 4. Sharing network infrastructure (mobile solutions) [13, 23, 24].

Layer	Component	Description
Physical infrastructure	NodeB and co-location	Masts and antenna systems
RAN connectivity sharing	Site sharing	Only non-intelligent equipment at base station sites are shared. For example masts and power supplies, possibly also antenna systems.
	BS sharing	The BSs (and "below") are shared, but operators have their own radio network controllers and core networks.
	RAN sharing	The whole RAN is shared, but core networks are still operator specific.

2 Conclusions

In Portugal, the regulator (ANACOM) concluded in January 2009 the analysis of broadband markets, which includes the analysis of the market for wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location and wholesale broadband access market [14, 25]. One of the key developments was the imposition of a cost-oriented, open and nondiscriminatory access obligation to ducts, poles and other installations of public utilities (such as highways, railways, ports,

airports, water, transport, gas and electricity), which are suitable for electronic communications networks.

Innovations in the regulatory framework are required to extend the reach of efficient platform competition. Duct sharing is an innovation that can reduce barriers to new infrastructure investment by opening bottlenecks at the lower level of the value chain. Several studies [3, 9, 13, 23, 26, 27] found that the most efficient manner of entry for a supposed fixed line network operator involves the use of existing ducts and trenches. As the cost of constructing new trenches is high, it is a good option for network operators to enter into the market by renting space in the existing ducts and/or trenches. [27] argued that new entrant operators can use trenches and ducts from the incumbent infrastructure for a price, rather than building or upgrading their infrastructure.

It is fundamental that incumbent operators provide access to the civil works infrastructure, including its ducts, and give wholesale broadband access (bitstream) to the local loop, regardless of whether it is copper-based or fiber-based. However, at the same time, alternative operators should be able to compete on the basis of the wholesale broadband input while they progressively rollout their own NGA infrastructure. In some areas, especially those with higher density, alternative operators have introduced their own infrastructure. As a result, broadband competition has developed, which should result in more innovation and better prices for consumers.

Acknowledgments. UNIAG, R&D unit funded by the FCT – Portuguese Foundation for the Development of Science and Technology, Ministry of Science, Technology and Higher Education. Project n.º UID/GES/4752/2016

References

1. E. Commission, EUROPE 2020 - A strategy for smart, sustainable and inclusive growth, Brussels (2015)
2. Trestian, R., Muntean, G.: Convergence of broadband, broadcast, and cellular network technologies: Igi Global (2014)
3. Jaag, C., Lutzenberger, M.: Approaches to FTTH-regulation: an international comparison. In: Second Annual Conference on Competition and Regulation in Network Industries, Brussels, Belgium, p. 23 (2009)
4. Andersen Management.International, Pricing Shared Access in Sweden, Post-of Telestyrelsen, Sweden (2004)
5. Analysys-Mason, Telecoms infrastructure access – sample survey of duct access. Ofcom, London (2009)
6. EuropeanCommission, Broadband Coverage in Europe 2013, European Comission (2014)
7. Pereira, J.P.R.: Next Generation Network (NGN) challenges on access networks. In: Rocha, Á., Correia, A.M., Adeli, H., Reis, L.P., Teixeira, M.M. (eds.) New Advances in Information Systems and Technologies Volume 2. AISC, vol. 445, pp. 341–350. Springer, Cham (2016). doi:10.1007/978-3-319-31307-8_36
8. Pereira, J.P.R.: Broadband access and digital divide. In: Rocha, Á., Correia, A.M., Adeli, H., Reis, L.P., Teixeira, M.M. (eds.) New Advances in Information Systems and Technologies, Volume 2. AISC, vol. 445, pp. 341–350. Springer, Cham (2016). doi: 10.1007/978-3-319-31307-8_36

9. Marcus, J.S., Elixmann, D., Wernick, C.: Next Generation Networks (NGNs). European Parliament, Brussels (2009)
10. Sirbu, M.A.: FTTP networks: topology and competition. In: OECD Workshop on Fibre Investment and Policy Challenges, pp. 1–31, Stavanger, Norway (2008)
11. Iatropoulos, A.D.: Broadband investments analysis using real options methodology. Commun. Strat. **55**, 21 (2004)
12. CSMG, Economics of Shared Infrastructure Access, London, UK (2010)
13. Onwurah, C.: Infrastructure sharing - promoting competition next generation fixed access. In: Presented at the Network Sharing: Strategy Forum for Telecoms Operators, Prague, Czech Republic (2008)
14. European-Commission, Portual: Main market developments, European Commission (2011)
15. ANACOM: A evolução para as NRA e o acesso à fibra ótica (2016)
16. OECD, Geographically Segmented Regulation for Telecommunications, OECD Digital Economy Papers, vol. 173, p. 78 (2010)
17. OFCOM, Application of spectrum liberalisation and trading to the mobile sector, OFCOM (2009)
18. Xavier, P.: Geographically segmented regulation for telecommunications, OECD (2010)
19. Analysys-Consulting, Comparative Costing of Wireless Access Technologies in Australia (Final report for the ACCC) (2006)
20. Analysys-Consulting, Analysys cost model for Australian fixed network services, ACCC, Australia (2009)
21. Telstra, Telstra efficient access cost model – economic issues, Ovum (2009)
22. IDATE, Broadband Coverage in Europe, Information Society (2009)
23. Johansson, K., Zander, J., Furuskar, A.: Modelling the cost of heterogeneous wireless access networks. Int. J. Mob. Netw. Des. Innov. **2**, 58–66 (2007)
24. Pereira, J.P.R.: Architecture for wireless grids. In: Rocha, A., Correia, A.M., Costanzo, S., Reis, L.P. (eds.) New Contributions in Information Systems and Technologies, Volume 1. AISC, vol. 353, pp. 1045–1054. Springer, Cham (2015). doi: 10.1007/978-3-319-16486-1_103
25. BEREC, The impact of technological and market evolution on market definitions in electronic communications: the case of spectrum, Body of European Regulators for Electronic Communications (BEREC), Netherlands (2010)
26. Vega, R.D.: NGANs and the geographical segmentation of markets. In: OECD Workshop on Fibre Investment and Policy Challenges, pp. 1–18, Stavanger, Norway (2008)
27. Europe-Economics, Pricing Principles for the Unconditioned Local Loop Service (ULLS) in Australia, Europe Economics, London, UK (2009)