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Value Network Analysis for NGOA networks and its impact on costs and benefits for the different actors involved

Abstract

Nowadays, one of the hottest topics in the telecommunication domain concerns the viability of the Next Generation Optical Access (NGOA) networks: access networks based on fiber technologies, such as Fiber-to-the-Home (FttH). In the past, telecommunication networks in Europe were in the hands of the incumbent: the (often public) telecommunications operator. This actor still has a quite stable market position and is not eager to invest in the deployment of NGOA networks. Therefore, other paths need to be investigated and other actors need to be involved in the rollout and operation of such networks in Europe. This paper will investigate which actors (both public and private) can participate (actively or passively) in this process.

Because of the involvement of multiple actors, it is important to map those actors to the role(s) they take up and model the interactions between them. After this multi-actor analysis, each actor can be lifted out and investigated separately to identify his case-specific costs for and benefits from participation in the deployment and exploitation of NGOA networks. Apart from the well-known direct costs and revenues, it is important also to take indirect benefits, like the socio-economic development of the region, into account because they can be of great significance to public actors such as governments or municipalities.

This research will analyze and evaluate the (social) costs and benefits for each actor by developing a quantitative model that is able to calculate the costs and benefits for all actors separately. Based on a first qualitative analysis, two preliminary conclusions can be drawn. First, cooperation between different partners (public and/or private) seems to be necessary when evolving towards NGOA networks. Second, this research focuses on indirect benefits, as they can persuade public actors to co-invest in the deployment of fiber-based access networks.

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Keywords: Next Generation Optical Access, Fiber-to-the-Home, Multi-Actor, Value Network, Public Benefits, Social Cost-Benefit Analysis

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1 Introduction and motivation

Although most of the telephone networks in Europe were initially set up by private firms, governments soon understood the importance of these networks and took the responsibility of providing everyone with the possibility to connect to the network. As a result, the national copper network in many European countries was owned and exploited by one (public) company. Examples of these incumbent operators include KPN in the Netherlands, BT in the United Kingdom and DT in Germany. In order to promote competition and evolve towards one European market for Telecommunications, the European Union published the “Green Paper on the development of the common market for telecommunication services and equipment” in 1987 [1]. In 1994, the EU decided to liberalize the market for services completely and obliged the incumbents to open up their network starting from January 1st, 1998.

Liberalization made room for competition. In those countries where a cable network was present, this level of competition was even higher because of the emerging possibility of two-way traffic (and thus broadband connection) on the cable network. Despite of this higher level of competition, telecom operators (both on DSL and cable networks) are not eager to invest in new infrastructure for the last mile. Their position in the market is quite stable and the fear of new regulations on open access for NGOA networks (Next Generation Optical Access networks, or access networks based on fiber technologies, such as Fiber-to-the-Home (FttH) networks) removes the incentive to deploy a new network.

The European Union recognizes the need for higher bandwidths in the near future and has set clear goals in its Digital Agenda: all Europeans should have access to Internet speeds of above 30 Mbps and 50% or more of European households should have subscribed to Internet connections above 100 Mbps by 2020 [2]. To promote the rollout of NGOA networks and competition, the EU changed its legal framework in 2010 towards two main aspects [3]. First, a clear definition of State Aid is provided: State Aid is public money that has to confer a selective, economic advantage to undertakings. Three exceptions are allowed: the Market Economy Investor Principle (where a government acts as a genuine investor in forming a PPP to carry out an NGOA project and also bears his part in the losses), Service of General Economic Interest (for services that are of general public interest and cannot be viable under normal economic conditions) and the distinction between White, Grey and Black areas (State Aid is only allowed in white areas, where no infrastructure is available or likely to be built in the next three years). Second, the EU revised the law on Electronic Communications Regulation to prevent a return to a monopolistic broadband market by imposing a set of obligations for SMP (Significant Market Power) and non-SMP players.

Since incumbent telecom operators don’t seem to take the initiative, some European cities have found other solutions for deploying an NGOA network. These examples include the investment of the municipalities themselves (Stokab in Sweden [4], Glasvezelnet Amsterdam [5] where the city of Amsterdam acted as a genuine Market Investor), the involvement of utility network owners (Wienström in Vienna [6], Stadtwerke Schwerte in Germany [7]) or even the participation of the inhabitants of the region (OnsNet Neunen in the Netherlands [8])!

The evolution towards the involvement of multiple actors has triggered many researchers over the last years. A wide literature about the possibilities of public-private partnerships (PPP) grew up [5, 9]. Gómez-Barrosso and Feijóo discuss the intervention of public parties in the market and argue that stimulating competition by allowing entry into the market brings far greater benefits than privatization [10]. Falch and Henten elaborate on the combination of public and private funds for investing in broadband infrastructure [11]. Many reports look deeper into the opportunities and threats of government intervention in the deployment of NGOA networks [12]. When investigating the influence of multiple actors in the rollout of new networks, literature mainly focuses on the regulatory aspects and possible investment initiatives. This paper will deflect from this path and focuses on defining the typical roles in the telecom domain and the actors taking up these roles. Based on a matrix framework with network layers, network parts and network lifecycle phases (based on [13]), different cases of mapping actors to roles will be developed. The interactions between these different actors (monetary and material streams that flow from one actor to another) will be modeled using the Value Network approach proposed by Allee [14].

Once the roles taken up by the actors are specified and their interactions modeled, the different actors can be looked at separately to identify their specific costs and benefits. Of course, these will differ depending on the roles taken up and on the other actors involved. The modeling of the costs of an NGOA network is a well investigated research domain. Different design models and various specific case calculations can be found in literature. Casier developed a techno-economic model for calculating the total cost for deploying a fiber-based access network [15]. Bauters and Van der Wee extended this model to a modular Java-based calculation tool [16]. These and other sources ([17, 18]) give good estimations on the capital expenses. The costs for operating the network are much lower, but not negligible [19, 20]. Overall revenues for an NGOA connection or revenues for different services have been described before [21-23]. Modeling the revenues per actor on the other hand is a relatively new research domain.

In order to come to an answer to the question whether it is profitable for each actor to invest in the network, it is important to also take the indirect benefits into account. These effects, like the socio-economic impact of fiber-based access networks on the development of the region can be of great importance when defining the stimulus for public actors. The significance of incorporating these kinds of benefits has emerged in the last years. Some first examples of sectors and services that could entail these effects are being described [24] and categories have been proposed [25, 26]. Clear methodologies for translating these effects into a monetary value have however not yet been developed.

This paper aims at developing a quantitative model that is able to calculate the costs and benefits for each individual actor. To arrive at this model, Section 2 will continue defining the typical roles in the telecom domain and the actors taking up these roles. The actors can then be mapped to the roles and the interactions between the actors can be identified for different European cases. Section 3 takes these in- and outflows of value to define a methodology for calculating the profits for each actor separately. Section 4 elaborates on the indirect benefits and methodologies to quantify them. The paper summarizes the main goals of this research and draws two preliminary conclusions (the necessity of cooperation between multiple partners and the importance of indirect benefits) in Section 5.

2 Defining NGOA Value Networks

The recent trends towards the involvement of multiple actors in the telecom domain call for an analysis of the interactions between these actors. This section will first elaborate on the typical roles within the telecom domain and describe which actors can be involved, and continue with mapping the actors to these roles and the identification of the value streams between the actors for different scenarios.

2.1 Typical roles or responsibilities within the telecom domain

2.1.1 Network layers

A broadband network can be split up into different layers [27], from which three important roles can be defined (Figure 1). The layered structure can be easily interpreted as an extension of the classical OSI-model [28] towards fiber-oriented networks.

The Physical Infrastructure Provider (PIP) is responsible for obtaining Right of Way (RoW, the right to open up the streets) and performing the digging works itself, installing ducts and fibers or blowing the fibers afterwards. The PIP can also take care of other passive infrastructure, such as the housing of the Central Office (CO), installation of empty racks, provisioning of man- and hand holes, and so on.

The Network Provider (NP) deploys and operates all the active equipment necessary to provide an end-to-end connectivity between the customers and the CO. They install specific equipment at the CO and at the customer's premises and are responsible for the other active equipment (like switches, splitters…) in between.

When an end-to-end connectivity is present, the Service Provider (SP) can use the active network to offer services. His responsibility is to install the service-specific equipment (e.g. a set-up box for digital television) and to send the right content and applications to its subscribers. It is important to mention here that we consider only on the local service providers that receive direct revenues from their customers through subscriptions and not the over the top players like Google etc. that get their main income out of advertising.

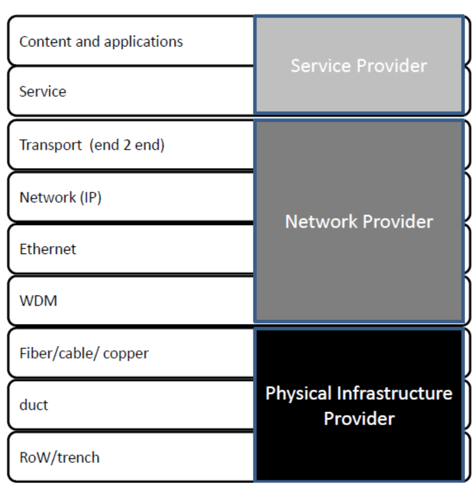

Figure 1: Roles in a telecom network

The roles discussed in the previous paragraph should be carried out in every lifecycle phase and every part of the network. Therefore, the framework is extended to a matrix format indicating these different lifecycle phases and network parts (Figure 2) [13]. Each cell within this matrix contains the network layers indicated in Figure 1.

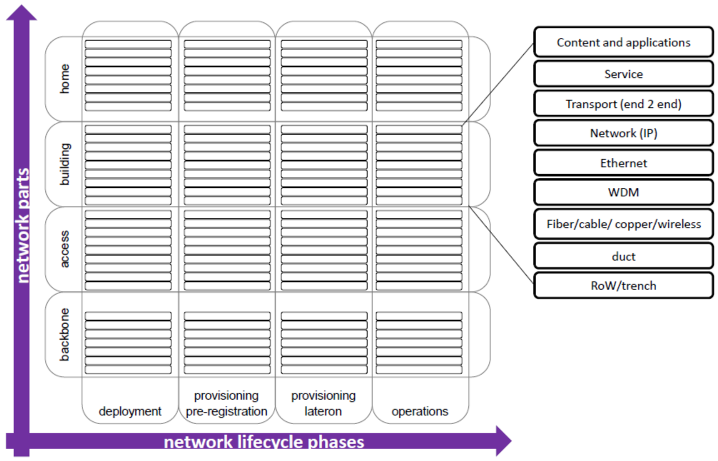

Figure 2: Layered framework for business model definition

2.1.2 Network lifecycle phases

The network lifecycle phases (x-axis) indicate the four steps that typically need to be undertaken to construct an operational network. Once the planning (choice of topology and technology) is agreed upon, the deployment of the network can begin (**deployment phase**). This phase consists of two major parts: the inside and outside plant. The deployment of the inside plant includes the installation of all active equipment (e.g. OLT cards, switches), passive equipment (e.g. racks, patch cables) and other necessary equipment (e.g. cooling, electricity) in the CO and possible street cabinets (SC). The outside plant is the part of the network that connects the customer's premises to the CO and consists of opening up the street, installing the ducts and possible micro-ducts, and blowing fibers.

The second and third phases consist of the **provisioning of the customers**, where an end-to-end connectivity between the CO and the customer is set-up. These phases require adjustments to both the inside and the outside plant. In the outside plant, the last part of the physical connection needs to be made, which includes digging on the property of the customer, boring a hole through the wall etc. Then the customer needs to be actively connected: this implies making the right links in the CO and SC's, installing the Optical Network Unit (ONU) and other service-specific equipment inside the house of the customer. The distinction between the second and third phase can be found in the moment of subscribing. The second phase treats **pre-registered customers** (customers that have subscribed before or during the physical rollout of the network), while the third phase looks at **provisioning customers later on** (after the deployment of the public network is completed). This has an important impact on the costs, because for pre-registered customers, economies of scale can be applied when connecting multiple customers in a single street.

The fourth phase starts when the network is **operational** and will continue until the end of its lifetime. It includes all processes necessary to keep the network up and running: operations, administration and maintenance processes, both for the inside plant (maintenance and reparation of active equipment in CO and SC's) and the outside plant (e.g. repairing of cable cuts). Furthermore, the customer relationship management (helpdesk, billing etc.) and some continuous costs (energy, renting of floor space etc.) are included in this phase.

2.1.3 Network Parts

Next to the different lifecycle phases, we also define four network parts (y-axis): backbone, access, building and home. The **backbone** network is the core network and corresponds to the high capacity connections between different CO's. This network segment already consists of fiber and the business models used here are completely different from those possible in the **access** network. Therefore, this part of the network will not be discussed further. The access network connects all the buildings in one specific geographical area to one CO. In the case of multi-dwelling units (MDU), the third part (**building**) of the network is also important and foresees in the connection to the door of the different apartments. The fourth and last part of the network (**home**) includes the equipment and wiring within the single houses (single-dwelling units, SDU) or apartments.

2.2 Description of the potentially involved actors

Now the definition of the roles in the deployment and exploitation of NGOA networks is presented, this section will briefly describe the most important actors involved in the telecom domain and link them with the roles they can take up. For each actor, some indications about the possible costs and benefits will be discussed. These costs and benefits will be further investigated and evaluated in Section 3 and 4. An overview of the actors discussed can be found in Table 1.

Table 1: Summary of the possible actors involved in the deployment and operations of an NGOA network

Actor	Public/private	Role
Telecom operator	public and/or private	PIP, NP, SP or combination
New entrant	public and/or private	PIP, NP, SP or combination
Municipality	public	PIP or PIP+NP Cooperation in deployment
Utility network owners	public and/or private	PIP or PIP+NP Cooperation in deployment
Housing organizations	public and/or private	PIP (in building) Financial support Aggregation of demand
Public authorities, regulators and governments	public	Financial support Aggregation of demand Regulatory framework
Equipment vendors	private	Equipment vending
End-customers (both business and residential)	private	Consuming services PIP and or/NP in building and/or in home

Within the historical context of telecommunication networks, typically one (public) **telecom operator** took up all roles described above (e.g. DT in Germany, BT in the UK…). Those players typically have a stable market position, since their networks are the result of a long-term process with a lot of financial State interventions. Their main cost is keeping the network up and running and their revenues are ensured due to their stable customer base. Incumbents are not eager to invest in new networks due to the uncertainties regarding the regulatory framework for NGOA networks: will these operators be obliged to open up a newly deployed network to **new entrants**?

Because of the reluctance of the incumbent, the roles for a Fiber-to-the-Home (FttH) network are more split up among less the telecom-oriented actors. Several case studies in Europe prove the positive effect of the involvement of other actors on a deployment of NGOA networks.

Municipalities can play an important role in the process towards deploying an NGOA network. They can be actively involved as a PIP (as is the case for the public company Stokab in Stockholm, Sweden); they can form a Public Private Partnership (PPP) with private companies (e.g. Glasvezelnet Amsterdam) or financially support a third party, as long as their action fits within the regulatory boundaries imposed by the EU. Of course, the costs for the actor strongly depend on the role(s) they take up, as do the direct revenues. However, the public benefits of having a high-speed broadband network covering the entire city or municipality are independent of that role. We think of savings for a city's administration and communication, enhanced attractiveness of a region for inhabitants, international companies, tourists and many more.

Since there are a lot of **utility networks** (water, electricity, gas) that require a buried installation, these parties can also take up the PIP role and combine the deployment of the telecom network with the rollout of their own infrastructure. The costs for digging can then be allocated to the different networks. Another, more likely, possibility for utility networks to participate in the passive infrastructure of an NGOA network, is to allow the PIP (can be a telecom operator, city or third party) to lay ducts in the trenches that were already dug for the installation of the utility network. This latter party can then recuperate a small fee from the PIP and hence reduce their digging costs. Tahon et al. calculated a reduction in digging costs of about 50% and a reduction in installation costs of around 20% [29]. Since utility networks usually don't dispose of the right technical knowledge about telecom specific equipment, it is unlikely that a utility network will take up an NP or SP role. Successful business cases in Europe exist (e.g. Wienström in Vienna [6], Schwerte in Germany [7] and Waoo! In Denmark [30]), the NP and SP role there is taken up by a separate subsidiary.

It is obvious that the deployment cost per household is much smaller for dense urban areas then for rural regions (mainly due to the smaller distance between the houses). Even more profitable are the dense urban areas with MDU's, since the buried cable length can be split between more households. In a lot of European cities like Amsterdam, Berlin or Stockholm, a lot of these MDU's are owned by a limited number of **housing organizations**. It is therefore important to also investigate if these organizations can (actively) participate in the deployment of the network.

Concerning the in-building network (the connection of the different apartments), housing organizations can definitely take the initiative for the deployment of the fiber cables. The remark about technological knowledge of telecom equipment made above for utility networks can be repeated here. On the other hand, it is quite unlikely that a housing organization on its own will start up the deployment of the access network, but they can be of importance by financially supporting initiatives from other parties or by aggregating the demand (and thereby ensuring a fixed number of pre-subscribed customers).

By offering a secure, stable and fast Internet connection to their residents, housing organizations can improve their competitive position and increase the value of their property. They can also integrate the connection fee in the requested rent and benefit from the economics of scale (investment for the multiple buildings versus the monthly connection cost for every single apartment).

The next actor discussed is actually a group of public bodies: **regulatory institutions, public authorities, governments**… We group these actors because they have a big influence on each other and more or less the same interest and power. Active participation in the deployment and exploitation of an NGOA network is difficult due to the current laws about market distortion of public parties [31] and the European directive on the liberalization of the telecommunications market [32]. They can impact the development of NGOA networks by imposing regulations or laws, by aggregating demand (public administrative buildings, hospitals, schools etc.) or by providing financial aid in the form of subsidies for private parties or end-customers. A concrete example of the influence of the authorities can be easily found in the opportunity for synergies with utility networks. Government or local authorities can for instance issue a law or recommendation that obliges the utility networks to cooperate ("the streets can only be opened once every two years") or provide subsidies to install empty ducts.

The benefits for these actors will be investigated as the positive effects for the entire region or country. Things like effects on employment rate and GDP, but also possible increases in taxes due to an enhanced number of paying companies or inhabitants directly come to mind. The methodology for quantifying these effects will be discussed in Section 4.

Apart from the actors in the center of the value network (related to the PIP, NP and SP roles), some other actors are needed to complete this value network: equipment vendors and software developers at the supply-side and end-customers (both residential and business or industrial) at the demand-side.

The **suppliers** are assumed to operate quasi-independent of the center of the value network. They will of course have higher incomes if they can enter into a contract with the PIP of a large network, but since the main part of the deployment cost is covered by digging works, the equipment vendors will not be able to provide the technology push towards FttH by for example decreasing the cost of equipment.

Rolling out an FttH network will provide the **end-customers** with a better and faster broadband connection. They will be able to use the newest, high bandwidth consuming applications, such as HDTV, or more important a combination of current applications that can be used at the same time. The cost for the end-customer can be easily referred to as the monthly subscription fee they have to pay for each service. The more services the client subscribes to, the more he pays, although this relationship is not linear (prices for triple play versus prices for the separate services). A German study estimated the average willingness to pay for higher bandwidths (up to 50 Mbps) to be €6.85 more than the current monthly fee for cable or DSL (current bandwidths varying between less than 1Mbps to over 16 Mbps) [33]. In return for this higher monthly fee, customers will experience a higher quality of life, better healthcare, better security etc.

The benefits for business customers are even higher, since they also include teleworking, real-time video-conferencing and so on. Here, the higher costs for the increased bandwidth should be compared to the savings in travel time and costs in order to determine the willingness to subscribe.

2.3 Mapping actors to roles and identifying their interactions

After the definition of both roles and actors, the actors are now mapped to the roles and their interactions are investigated. This will be done using a value network approach as described by Allee [14, 34].

Allee describes the value network as visual representation of an organization. Apart from actors and roles, she adds two other main elements: deliverables and transactions.

- **Transactions** (also called activities) indicate that value flows from one actor to the other. They are represented by arrows so that the link between the actors is directional. Two types of transactions are distinguished: tangible (direct flows concerning product and revenue) and intangible (indirect benefits). In the visual representation, tangible transactions will be represented by solid lines while dashed arrows picture the intangible transactions.
- **Deliverables** are the things that are transported along the transaction arrows, like end-products, documents, monetary or knowledge flows.

An example of a simplified value network is given in Figure 3**Error! Reference source not found.**.

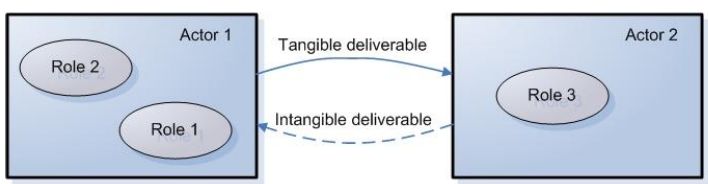

Figure 3: General concept of Value Network visualization

The previous sections were rather theoretical in describing the different roles, actors and value network approach. To make things more clear and to demonstrate the use of these concepts, some examples will be worked out.

2.3.1 Example 1: Stockholm, Sweden

The first example describes the rollout of an FttH network in the city of Stockholm, Sweden. Figure 4 visualizes the mapping of the actors on the roles. The backbone part of the network is left out, since this is not the focus of the study. Also, in Stockholm, all actors are responsible for all network lifecycle phases. However, this is not always the case: a public company can for instance deploy the passive network and later hand it over to a private company, that becomes then responsible for the operations of both the passive and active infrastructure (e.g. Waoo! in Denmark [30]).

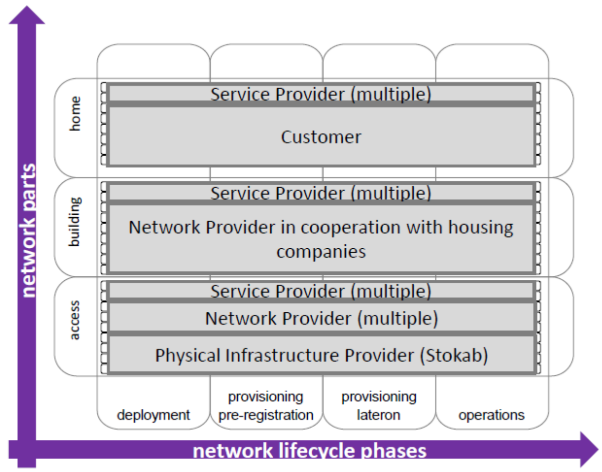

Figure 4: Mapping actors to roles for the example of Stockholm

In order to create competition in the telecom sector, the city of Stockholm founded a public company in 1994: Stokab [4, 35]. By rolling out a dark fiber, operator-neutral network, the goal of Stokab was to stimulate the telecom market and ICT development in the Stockholm region and thereby promote economic growth. Stokab is only responsible for the passive infrastructure and does not own any active equipment. They lease out dark fiber to independent network providers for less than it would cost them to build their own network. This ensures that the digging works and the resulting burden for the residents are limited to the minimum.

The network providers lease the dark fiber from Stokab and light it up in order to provide end-to-end connectivity to the customers. The city's internal network is operated by one public NP (S:t Erik Kommunikation) while several private NP's operate the network for residential users.

The real competition in this model lies in the service layer. More than 90 service providers offer services using the Stokab's network. Each network provider has contracts with several service providers, from which the end-customers can choose. Of course, this level of competition has a positive effect on the prices for the end-customers.

Within the building part of the network, the housing company that owns the building, contracts one single network provider who is then responsible for providing end-to-end connectivity to the residents of the building. The latter can then choose which services they want to subscribe to. Within the apartments, the resident itself is responsible of installing the right equipment for the services he or she subscribes to (or can contact the service provider to install it for them).

A high-level representation of the value network for the FttH network in Stockholm is given in Figure 5. The most important value streams are indicated: revenue streams from end-customer to SP, from SP to NP, from end-customer to the housing association and from the NP to the PIP. One example of intangible deliverables is given: the indirect benefits for the city of Stockholm.

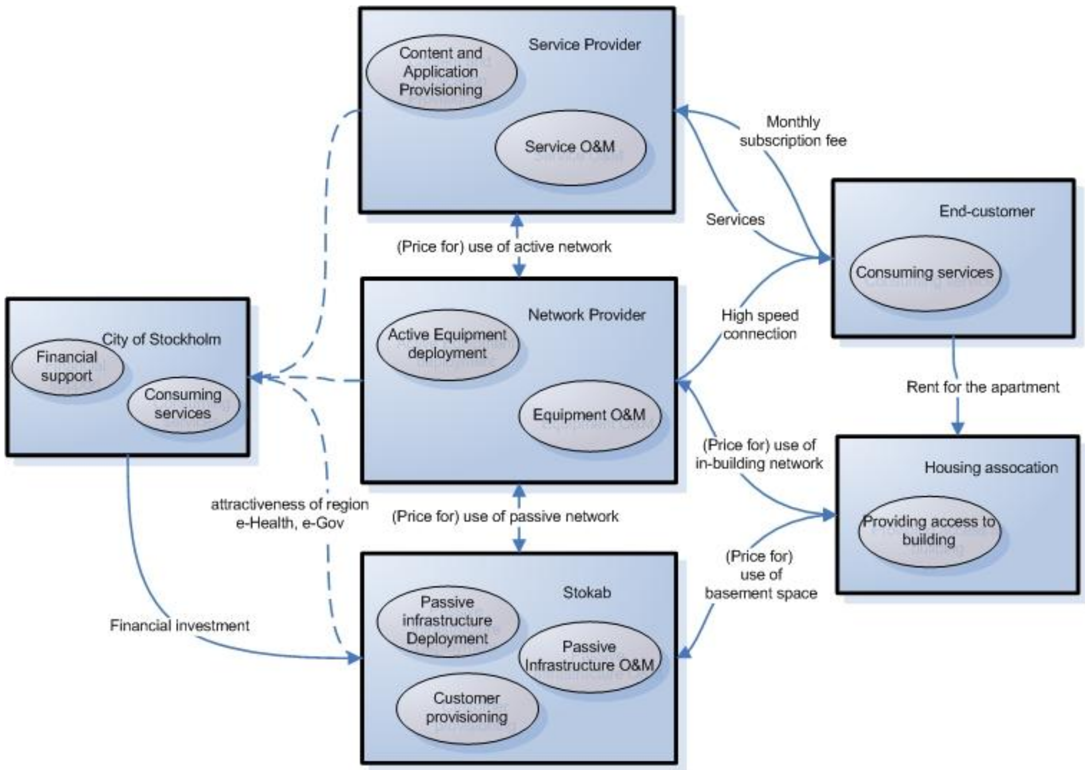

Figure 5: Value network for the FttH network in Stockholm

2.3.2 Amsterdam, the Netherlands

From the previous example, the role of the municipality (city) immediately catches the eye. The same holds for Amsterdam, where the city invested one third of the total sum for the passive infrastructure in a Public Private Partnership (PPP) called Glasvezelnet Amsterdam [36]. The mapping of the actors to the roles is quite similar to that of the network in Stockholm; the main difference is that there is only one network provider in Amsterdam.

2.3.3 Schwerte, Germany

A totally different case can be found in the rural area of Schwerte in Germany [7]. There, the local utility network took up all roles (vertically integrated operator). The value network here is much easier because it consists of a limited number of actors: one actor installing and operating the entire network and offering services, the end-customers and the region in general (for the public benefits).

2.3.4 Other cases

Other regions and cities in Europe are currently under study (the Netherlands, Greece, Norway…) The differences between these cases are significant, but they have one major characteristic in common: the involvement of a public party (municipality, utility, government…). The introduction to this paper already mentioned the hesitancy of the current telecom operators towards rolling out NGOA networks. These two findings combined lead to a general conclusion of the importance of the involvement of public actors for the success rate of an NGOA network deployment project.

3 Cost-Benefit analysis when multiple actors are involved

After having identified the different actors, roles and interactions for several scenarios, this section will focus on the costs and benefits and how they can be calculated for each participating actor. We start by providing an overview of costs and revenues to continue with looking at each actor individually and defining the methodology to allocate costs and benefits to these separate actors.

3.1 Costs and Revenues

The modeling of the costs of an NGOA network is a research domain in which al lot of work was performed already. Different sources ([15, 17, 18]) estimate the cost of passing a home (having the fiber in the specific street) at 800 to 1500 euro, the cost of connecting a home (having the fiber in the street and to the home, as well as the active equipment necessary to establish a connection) at about 2000 euro. The major part (about 50%) of these expenditures is covered by the deployment costs for a Greenfield scenario [37]. In the case of a Brownfield scenario, this share increases to about two thirds of total costs [18, 38]. Of the remaining third, about 70% goes to service provisioning (connecting the customers to the network) and 30% is spent on keeping the network up and running (maintenance and repair, customer relationship management…). When looking more closely at the deployment costs, the trenching cost makes up of about 80% of all deployment costs in both P2P (point-to-point) and P2MP (point-to-multipoint) scenarios for an all-buried case [39], which is immense.

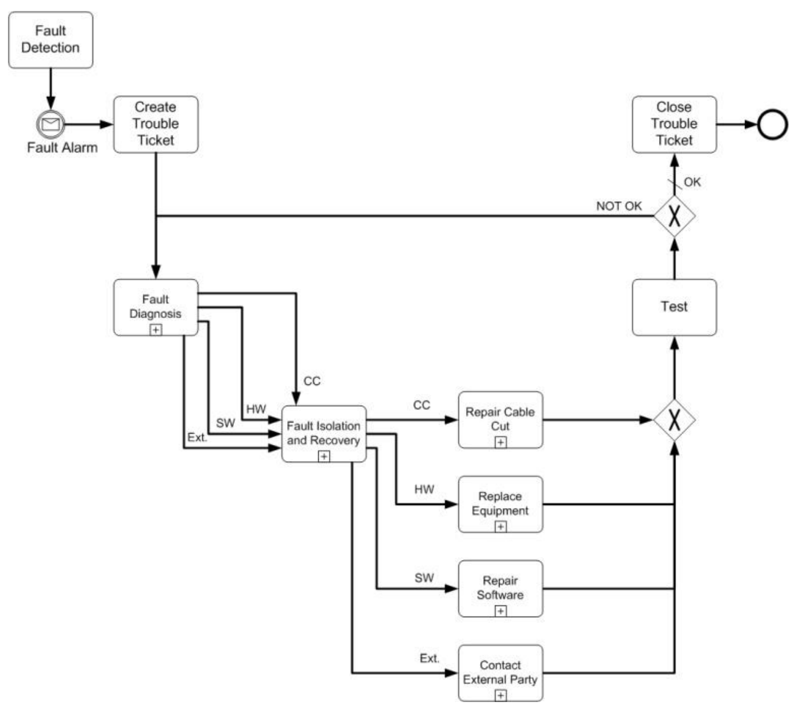

Figure 6: Representation of the fault reparation operational process

The costs for operating the network are much lower, but not negligible. In [19], a model for designing and calculating the operational expenses of a network is being presented. To thoroughly describe all the aspects of the operational process, the latter is divided into sub-processes, which can be further split into sub-sub-processes. This process of dividing can be iterated until the desired level of detail is reached (until the analyst reaches the building blocks: small sub-processes that can be easily and unambiguously be described). One example of an operational process (the detection and reparation of a fault) can be found in Figure 6. The visualization technique used is Business Processing Modeling Notation (BPMN), which is a standardized graphical notation for drawing business processes in a workflow [40]. The main advantage of splitting the processes into elementary building blocks (the desired level of detail) expresses itself when allocating the costs. It is clear that it's much easier to find the right cost driver for small building blocks than for entire operational processes (see also section 3.3).

When it comes to determining the revenues for each actor (of course mainly focusing on service provider, network provider and physical infrastructure provider), not much research is being performed. Numbers for the total monthly fees customers want to pay for a connection or for different services can be found more easily. Lannoo et al. estimate the revenues for a connection to be equal to what is now charged for a VDSL or HFC connection, ranging from €25 to €60 for residential customers [22]. Rosston, Savage and Waldman used choice experiments in a nationwide survey in the United States of America to estimate the marginal willingness to pay for improvements in Internet services [23]. They found that the representative household is willing to pay $20 per month for an increased service reliability and $45-48 per month for higher speeds. According to a German study [33], German households are willing the pay an additional €6.85 per month for higher bandwidths. Ida and Horiguchi estimated the willingness to pay for services in Japan [21] and found that these range from about $1 (for TV phone) to about $28 (for terrestrial digital broadcasting). The challenge here is to find a way to allocate these revenues to the different actors involved.

In order to arrive at positive business cases for (public) actors, it is important to also take into account indirect revenues (also referred to as social benefits, uncaptured value or indirect effects). These include benefits for the specific actors in a broader social, cultural and political scope. Hayes gives an exhaustive list of indirect benefits within the scope of a national broadband network in Australia. He includes advantages for the educational and health sector, new developments for e-government and electricity grid services and possibilities for businesses and their employees (teleworking, cloud computing etc.) [24]. The importance of including these effects in the analysis is beyond dispute, but the main problem is the difficulty of translating social or cultural benefits in a monetary value. Therefore, this aspect will be discussed in a separate section (Section 4).

3.2 Actor-specific costs and benefits

In Section 2.2, the different actors that can potentially play a role in the deployment and exploitation of an NGOA network were described and a first idea on their degree of participation was given. Table 2 gives an overview of the different actors and an indication of their specific costs and benefits. The list of costs and revenues for each actor is of course not exhaustive, but aims at giving a first indication on which costs and benefits will have the main impact and which ones should be shared amongst multiple actors. Important to notice is the difference in weight for direct and indirect revenues in between the different actors. Public bodies will get most of their benefits from indirect revenues, while private actors are more focused towards direct incomes (real flows of money).

Table 2: Actor-specific costs and benefits

Actor	Costs	Benefits
Telecom operator	Deployment and operations of the network and/or services (depends on role)	Monthly subscription fees Renting out of passive/active network
New entrant	Deployment and operations of the network and/or services (depends on role)	Monthly subscription fees
Municipality	Financial support Deployment costs for passive network (in PIP role)	Savings in city's administration and communication Enhanced attractiveness of region
Utility network owners	Passive equipment (in PIP role)	Reduction/ sharing of digging costs
Housing organizations	Network deployment within buildings	Direct revenues from higher rent Competitive advantage
Public authorities, regulators and governments	Financial support	Employment rate GDP Increased amount of taxes
Equipment vendors	R&D, production and distribution costs for specific equipment	Economies of scale
End-customers (both business and residential)	Subscription fees	Enhanced quality of life, security and healthcare etc. Savings through teleworking, video-conferencing etc.

3.3 Cost allocation

Once the costs and benefits for the system in total are defined and the most important ones for the different actors are known, they can be allocated to the individual actors. For some costs and benefits, the actor under study is the only one taking up these values. Others can be shared amongst actors and should thus be split up in order to avoid being counted twice. Different cost allocation methods have been suggested in literature [41], but this research will opt for the Fully Allocated Cost (FAC) method, because FAC allocates all costs to all actors involved in a fair way. Direct costs (costs made by one actor) are allocated to the specific actor, while shared costs (costs related to multiple actors) and common costs (costs related to the entire system, like administration) are shared amongst the actors involved based on an allocation key or cost driver. Figure 7 gives a visual representation of this method.

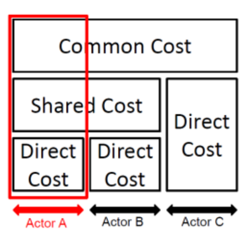

Figure 7: Fully Allocated Cost method

Once the costs and revenues are identified and allocated, a comparison between them needs to be made to determine the potential profit for each actor. The outcome of this analysis aims at providing a stimulus for the actor to participate in some way in the development of an NGOA network and can be summarized in the following simple equation:

$$profit = \sum_{in} values - \sum_{out} values > 0$$

If the outcome of this equation is positive, then the actor under study will benefit from participating in the rollout of a new network. Without the inclusion of indirect effects, the profit for the public actors will probably be negative. It is therefore crucial to enter these benefits into the equation. However, translating these intangible effects into a monetary value is a challenge. The next section will describe these benefits into more detail and propose some methodologies for quantification.

4 Indirect benefits: categorization and quantification

Indirect benefits are benefits for one actor, caused by actions of another actor. These effects are not limited to the telecommunications sector only, but spread out to the entire economic, social and cultural environment. They are especially important to take into account when convincing public actors to invest in the rollout of an NGOA network. This section will elaborate on what is understood when talking about indirect effects and how they could be quantified.

4.1 Categorization

Indirect effects, social benefits, the uncaptured value of FttH are all different names to define benefits the different actors can have from the presence of an NGOA network. The e-Health services can make sure that elderly can stay longer at home, e-Government results in large savings in the administration expenses of a city and so on. Although the domain of indirect benefits for networks is relatively new, the list of effects is already quite long and calls for some categorization. The author proposes here some ideas for categories that can serve as an input for methods for quantification. Since this research is work-in-progress, this list of categories is far from exhaustive.

The first category (**savings**) groups all the indirect benefits that indicate a difference in costs between the situation before and after the installation of the NGOA network. Examples include the reduction in travel time and costs for business employees and savings in the health sector.

Macro-economic data such as GDP, employment rate and level of education are frequently used to estimate the prosperity of a country or region. When measuring the impact of NGOA networks on these data, one is implicitly measuring the impact on the (economic) welfare.

The third category, **subjective data**, groups all indicators that strongly depend on the importance the targeted audience attaches to these indicators. Examples include the enhanced image of a certain region, the value attached to having a higher speed connection etc.

4.2 Quantification

Subdividing the effects into different categories is interesting, but doesn't give the possibility to actually grasp the advantage. In order to really see the benefits, these effects should be translated into a monetary value. This is however not a straightforward task. For each category shortly described above, a methodology for quantification will be proposed (Table 3).

Table 3: Overview of methodologies for quantification of indirect effects

Category	Methodology	Example
Savings	Cost comparison	Savings in travel time and costs Savings in e-Health sector
Macro-economic, statistical data	Input-Output Analysis Regression Analysis	Employment rate Education level
Subjective data	Survey	Image of the region of city

The first type, grouped under the name **"savings"**, is the easiest to calculate. The methodology that can be used to translate these effects into a monetary value is relatively straightforward and consists of comparing the situation before with the situation after the installation of the network. Time studies [42] can be used to corroborate the estimated time savings. For example, comparing the costs for keeping elderly longer at home to what it would costs to accommodate them in retirement homes leads to large savings in accommodation space and needed personnel. Analogously, it is quite easy to quantify the savings a city's administration can achieve with the deployment of an NGOA network by calculating the time savings for the employees and translating them in a decrease in Full Time Equivalents (FTE's).

The **macro-economic and statistical data** can be quantified using Input-Output analysis and/or Regression analysis. Input-Output analysis analyzes the dependency relations between the economic sectors to come up with a matrix of input and output coefficients integrating the different sectors of the economy. By matrix manipulation it is then possible to predict the effects from increased demand in one sector on all the other sectors of the economy. Regression of the variable of interest (GDP, employment rate or the fraction of highly educated people in the labor force) on a broadband index proves another useful concept. This technique investigates how the value of the dependent variable (the variable of interest) changes when varying the independent variables.

Both of these techniques are used by Katz et al., who found out that 541,000 jobs can be created when rolling out a nationwide network in Germany in the period of 2010 to 2020, of which 304,000 in the first five years (2010-2014) and 237,000 in the period of 2015 to 2020 [43]. Out of the grand total, 281,000 are jobs directly related to the deployment and operations of the network. Katz compares the total additional production from these jobs to total investment for the rollout of the nationwide network: €93,073 million output versus €35,933 million investment, which means that investing €1 will generate €2.58 in output. The paper however doesn't indicate a timeline for this high return on investment (payback period), nor provides an estimate of the amount of jobs that will be outsourced to foreign countries (for example for cable and equipment manufacturing). From reading the paper, it's also not clear what exact calculation method was used to end up with the published numbers. Therefore, the results of this study should be looked at more carefully before drawing final conclusions.

Subjective data are the most difficult to handle, because their importance depends on personal views. Quantifying these effects will therefore be almost impossible. A qualitative approach to this problem is conducting a survey with concrete questions to a large amount of professionals who are actively engaged in the community (e.g. community council members, managers of important local firms or administrations etc.). Through their hands-on experience and knowledge of its operations, they can make educated guesses about the impact of broadband on their municipality. Such a feat has been performed by Craig Settles who has surveyed a panel of 260 mostly senior level executives. They believe in positive effects of both wireless and fixed technologies on the local economy. However they are not convinced of the benefits for touristic attractiveness and underline that with respect to personal development (such as adult education, trainings, etc…) positive effects can be generated by deploying broadband, as long as other conditions (so-called broadband readiness of the inhabitants) are also favorable [44].

5 Summary and future work

The recent evolutions in the domain of telecom networks show trends towards the involvement of more actors, both public and private, collaborating in the deployment and exploitation of NGOA networks. This trend calls for a clear description of the role(s) each individual actor takes up in this process and a thorough analysis of how the different actors interact. Based on a matrix framework with network layers, network parts and network lifecycle phases, the actors are mapped to the typical roles that need to be executed when deploying and maintaining a network. The interactions between those actors on the other hand are modeled using a Value Network approach.

Because investment decisions for NGOA networks are not yet considered as high priority and are frequently postponed, calculating the potential profits for each actor involved can serve as a stimulus for them to invest. In order to perform this cost-benefit analysis, each actor is lifted out and his specific costs and benefits are calculated making use of the right cost allocation keys. This cost-benefit analysis should take into account the role(s) the specific actor takes up and should also stress the importance of incorporating social benefits. These effects, like the socio-economic impact of an NGOA network on a region or city, the savings that can be made from e-Health or e-Government or the traffic reduction that can be gained from working at home, are especially important to win over public actors like municipalities and governments to participate and/or stimulate investments.

Within this research, the goal is to develop a model for calculating and evaluating the costs and revenues for each actor separately. Qualitative case studies throughout Europe give a first indication towards the most important costs and revenues for each actor, which serves as a good starting point towards the further deepening of the model. The model can in a later stage be verified through interviews with case experts, by comparing the outcomes to other studies and/or by performing the whole calculation on an existing and fully deployed NGOA network. The positive results of the model for existing rollouts can then stimulate other lagging regions to investigate the possibilities for initiating the deployment of a fiber-based access network.

The work done so far confirms the trend towards the involvement of more non-telecom related actors. The involvement of public actors in particular seems to be inevitably connected to the successful deployment of NGOA networks, be it in an active or passive role.

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