MULTI-LEVEL BUSINESS MODELING AND SIMULATION

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Abstract: The rapid succession of technological advances leads to important convergences of applications, devices and networks. More and more firms, previously locked in a niche, are exposed to a more global market and interactions with other firms. Pushing a new offer on the market requires a thorough understanding of this altered market. In essence, pushing a new offer requires basic business modeling and simulation. Often, this is performed by making a "back of the envelope" calculation. This calculation quickly grows out of proportions if the novel business proposition requires interactions with many other parties (hardware, maintenance, cloud, etc.). In this paper, we present a scalable multi-level business modeling and quantification approach. It combines the intuitive structure and interactive discussions of a multi-user business modeling tool, while directly linking to a lower level for more technical modeling and simulation of costs and revenues. By combining these two levels of refinement, the business aspects are clearly separated from the calculation techniques, increasing ease and speed of modeling at the business side. Delegating the cost calculations to the more technical models allows for a truthful and reliable mimicking of the actual structure and costs. To achieve this, several detailed cost modeling languages are presented and linked to the higher level business modeling. Finally, this multi-level business modeling and simulation approach is applied to the case of an open access FTTH network deployment. The results clearly show the power of using such a multi-level business modeling and simulation approach.

1 INTRODUCTION

Increasing competitive pressure makes business model innovation an important issue for most companies. Especially collaborative business models, which require a strategic fit between various stakeholders involved, require an intensive interaction and consensus building related to assumptions, architectures and outcomes. Like many other creative processes (architecture, software design, new product development, etc.), business model innovation can also be supported by tools (Coenen 2010). However, while a few basic frameworks exist, tool development for collaborative business model innovation is still in its infancy.

Many business modelling approaches start from a conceptual visualization of the context of one offering on the market, typically of one firm (Osterwalder 2005) and (Al-Debei 2010). The extended notion of a multi-firm interaction with several offerings and objectives exists and is typically visualized by means of a value network (Pijpers 2011). Still, most approaches are aimed at visualizing the interactions, often around one central firm and looking at one final offering on the market. A more truthful representation of reality in a business model should be seen as a network or graph of actors, the activities they perform, and all kinds of interactions between these actors. In order to be useful in advanced analysis, such business model should be set up according to a standardized ontology for which we used the SIMBU method

(Coenen 2009) as a starting point. The simple but expressive ontology proposed there, allows for the creation of complex business models and permits the support of consecutive simulations, to give users a better basis for decision making.

Although a business model consists of smaller elements as roles, actors, activities, value streams, etc., this is much too high level to estimate costs, revenues, losses or profits. Traditional cost benefit analysis, on the other hand, takes a closer look at the economics of a new investment, starting from dedicated calculations (Analysys Mason 2008) in isolated cases and working with generic and reusable cost modeling languages and calculations (Van der Wee 2012). Making dedicated calculations requires every researcher to redo the modeling if they have no access to the original model. Additionally, it does not allow extending and linking to other models. Building complex models will benefit from reusability, verification, exchange between researchers and business experts and linking to other models. Additionally using domain specific languages as opposed to grand tools with many parameters, will increase the transparency and ease of reading and understanding. Combining both approaches by working with standardized, reusable, domain specific languages will increase the strength of the business models.

On the one hand business experts (e.g. CEOs, entrepreneurs) talk about the roles and interactions of the different actors in a business model when they want to introduce a novel product or service on the market. On the other hand, a cost-benefit analysis is typically built for an isolated business case (one actor only), using dedicated, purpose-built models. If both approaches can be captured with the right level of detail and domain specific intuitive models and linked to each other, this will lead to additional information on the full business model, as well as on the isolated business cases. The combination of approaches will allow business experts to work on a higher level and design the business model as links between more detailed cost-benefit models, e.g. cloud infrastructure, network installation, etc. These models are then delegated to technical experts and more detailed modeling languages. A repository of models and fragments at both levels will increase the applicability of the approach and the speed of prototyping business models. This paper presents the combined approach, which is under active research and development and is called hereafter the BEMES (Business Modeling and Simulation) approach.

In this paper, the BEMES approach is applied to a prototype business model for an FTTH case, where one physical infrastructure FTTH provider is installing a new FTTH network and opening up this network in a non-discriminatory way to all available network and service providers. The multi-level business modeling approach allows visualizing the main business interactions rapidly, and learns about the profitability of all actors at the same time. It also shows the ways one firm's failing business case can be made viable within the group of actors in the full business model.

In section II, the BEMES business modeling tool is rapidly introduced and then compared to some of the main existing business modeling approaches.

As mentioned above, the business models need to be complemented with a cost-benefit analysis in order to get correct and useful advice and information from the business model. Building a reliable cost-benefit analysis also benefits from using problem specific modeling languages. In Section III, an overview of existing and novel cost modeling languages (technical expert tools) is presented.

In Section IV, both levels of modeling are linked to each other. As a proof of concept, a multi-level model for an open access FTTH network is built and the results of this model are inspected.

Finally, Section V concludes by summing up the main findings of this work and by presenting future steps in the development and extension of this multi-level business modeling and simulation approach.

2 BUSINESS MODELING

People use business modeling with the aim to analyze the current functioning of a firm or an industry, identify challenges, and possibly propose better business configurations. When building the business model, users need a highly interactive tool for drawing and discussing on their view of the industry actors and their interactions. It should be sufficiently high level, and no detailed cost and revenue discussions or simulations should be necessary at this level. The BEMES Business Modeling, proposed in this paper, is based on the SIMBU method (Coenen 2009). It features a value-flow based approach, and uses a simple and intuitive ontology specifically designed to allow for collaborative business modelling.

With BEMES, building a business model consists in identifying every actor, their activities and the interactions between their activities. A business model configuration corresponds to a given business model with specific values (e.g. cost amounts, revenue percentages, etc.). It is easy to compare different configurations or scenarios by playing with these values within the given business model. It is also possible to compare different approaches in setting up a working business model by playing with the definition of the actors, the definition and repartition of the activities, and the definition of the relationships between the activities.

The following elements are required to get a both intuitive limited modeling set and a high expressivity of the model:

- The Actor represents a business model stakeholder.
- An Activity is undertaken by an actor.
- A Flow represents a relationship between Activities.
- A flow can either be a monetary flow or a flow of goods and/or services.
- Value Sharing represents the division of one monetary flow into multiple monetary flows.
- A Swim lane is horizontally oriented and groups all the activities of an actor.
- A sub model allows the business modeling to be itself hierarchically structured and is typically used to increase readability of the model.

In **Error! Reference source not found.**, a FTTH network is modeled, using BEMES. There are three Actors in this Business Model: (1) the Customer who buys network connectivity at (2) the Network Provider. This Network Provider, in order to be able to provide network connectivity needs (3) the Physical Infrastructure Provider, who provides physical network and connects customers. Arrows between the Activities performed by each Actor show the flows of money or services between the Actors' Activities.

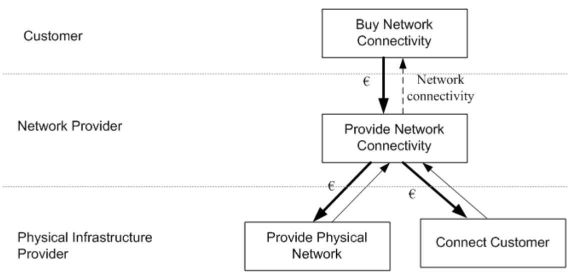

Figure 1: business model for the open access FTTH deployment

2.1 Comparison of BEMES to other Business Modeling

Various other business modeling approaches and languages exist and provides a comparison of BEMES to the mainly used other business modeling approaches. Every approach's main advantages and disadvantages are briefly discussed after the table.

One of the most salient business modelling approaches is the Business Model Canvas (BMC), based on Osterwalder's work (Osterwalder 2010). The Business Model Canvas is an ontological construct composed of 9 different categories participants (key partners, key activities, value proposition, customer relationships, customer segments, key resources, channels, cost structure and revenue streams) that need to be reflected on by a group of stakeholders. In the Business Model Canvas philosophy, a brainstorming session is done as a workshop, where all participants are asked to place Post-it notes on the canvas and discuss the implications of their actions.

TABLE 1: COMPARISON OF BUSINESS MODELING APPROACHES

	BEMES	e^3 value	Moby	BMW	BMC	CBM
Value Proposition	+/-	- -	+ +	-	+ +	+ +
Multiple Actors	+ +	+ +	+ / -	- -	- -	- -
Flexible Relations	+ +	+ +	+ +	- -	- -	- -
Value Net Completeness	+	+ +	+ +	- -	- -	- -
Value Net Simulation	+ +	- -	+ / -	+ / -	- -	- -
Ease of Use	+	- -	- -	+ +	+ +	+
Intuitivism	+	-	-	- -	+ +	+ +

Konnertz (Konnertz 2011) has proposed the collaborative business modelling (CBM) approach, which uses the Business Model Canvas by placing post-it notes on the canvas, generating a number of business models. After this is done, the business models are prioritised on the dimensions of attractiveness and effort. The models that are most attractive and take least effort are the ones that get most attention in the validation phase.

The Business Model Canvas method can be a powerful eye-opener and a good brainstorming framework, but it has some severe limitations if one wants to use it in an Open Business Model Innovation process. Firstly, the output of the Business Model Canvas method is a list of elements that can be bundled in scenarios. There is little support for making plain the relationships and interactions between the different elements. These relations and interactions make the difference between a business model as a static list of its constituents and a business model that is dynamic, as is the environment in which it will operate.

In terms of the open innovation perspective (Chesbrough 2005), some categories exist in the Business Model Canvas approach that can be linked to more open, multi-actor, value-networks, like key partners and channels. Still, the reflection engendered by the Business Model Canvas is mainly focused on one organization. In Open Business Model Innovation, several business actors collaborate to realize a value proposition in a relationship of mutual benefit. Finding a sustainable business model requires the perspective of the different actors to be made explicit and combined in a consensus business model.

Second, the Business Model Designer, described in (Weiner 2011), is built on a very broad ontology and allows the creation of very detailed representation of the components that are related to a value proposition, both within an organisation and outside of it. In particular, it allows the mapping of resources that an organisation should use in order to realise the value proposition, as well as the competitors that the organisation will have to deal with.

Third, the Business model wizard (BMW) allows for the creating of a business model by configuring 25 elements using an online form. The result is a business model that can be analysed and compared to the business models of existing organisations. While this is an easy to use approach, it focuses on one organisation and is constrained by the 25 elements that are part of the model.

Fourth, the e3-value modelling approach proposed by (Gordijn 2011) has tool support in the form of the e3 editor. This approach focusses more on the dynamics of the business model than on its constituents. The e3-value approach allows for the creation of highly formalized business models. However it requires a substantial amount of time in order to learn the interface and the modelling language.

In conclusion, BEMES is simple yet powerful. It allows for the expression of a complex business model, while being easy to learn by the modelers. The emphasis is more on the business knowledge of the modeler than on the business modeling skills of the modeler. Furthermore, the business modeling ontology allows for easy understanding of models created by others, which supports collaborative business modeling. Finally, models built using this ontology can be used to do high-level or detailed quantitative cost and revenue simulations.

3 COST MODELING

When making a business plan for the deployment of a novel open access FTTH network, close interaction between the physical infrastructure provider, network provider and any other involved parties will be necessary. The different parties will especially be interested to learn more on the costs they incur and have to pay to the other parties and to what final customer price this will lead. The FTTH network consists of the outside plant as well as the in-house installation and the installation of all central office equipment. It also requires operational processes in order to keep the network up and running and to sell services on top of this network. Much literature exists on how to build a business case for an FTTH network (e.g.(Analysys Mason 2008), (Van der Wee 2012), (Banerjee 2003) or (Medcalf 2008)). However it is hard for a researcher to follow the model in all these papers, as the models are typically not expressed in a format easy to read, easy to duplicate and use in other modeling steps. Additionally, each paper has a separate focus and only includes certain parts of total costs, making comparison very difficult.

Visual modeling languages help in making the business modelers and technical experts quickly aware of what it takes into account and how it will be calculated. A uniform and consistent translation from model to costs furthermore assures a correct calculation of the costs and deduces the right economic indicators from it. In what follows we link existing modeling approaches to each other and apply them in making a solid cost model for open access network architectures. Where necessary, we introduce and developed a novel modeling approach and link to more rigid specifications of the new language. Three cost modeling approaches are presented – infrastructure or network modeling, equipment coupling modeling and operational modeling – and one novel language for modeling the way revenues are estimated. The former three will be directly mapped to an activity on the business model, where the latter is linked to the monetary arrows linking these activities. All four combined allow rapid and reliably estimating the investment costs and revenues of the business case at hand.

3.1 Infrastructure Modeling

The largest cost of the network will come from installing the outside plant, i.e. deploying the fiber into trenches to connect all customers to the central office. Several models already exist for making an analytical estimation of this cost (Mitcsenkov 2013). Considering the size of this cost, a more detailed calculation can be made using an ILP formulation. In (Mitcsenkov 2013) a comparison is made between two analytical models and a full optimal installation calculation tool, and the street based estimation model will be used in the following example calculations. As an example area we use the city of Ghent, the third largest city of Belgium counting almost 235,000 inhabitants on an area of 156 km². The FTTH rollout is limited to the city center, with ca. 90,000 inhabitants or 42000 families on 20 km². (Gent, 2013).

3.2 Equipment Modeling

The second important cost is linked to the installation of the equipment in the central office. In order to calculate the costs of the installation of this equipment and taking into account all possible failures of this equipment in time and their replacements, we developed a novel modeling format. This modeling format is based upon previous work (Van der Wee 2008), and extended with indications of replacement period of the equipment (in accordance to either proactive maintenance or of failure rates), power consumption, floor space consumption, etc.

The model is based on (1) main drivers for equipment installation which are represented by arrows and will be used in the calculation of the required amount of equipment linked to these drivers. Every block from thereon will become a driver for next blocks once calculated. (2) Equipment blocks that hold all information on the cost, replacement time, etc. and (3) aggregators which will aggregate the incoming demands from different drivers and sub-equipment in a specific manner (sum, max, etc.). Finally all blocks are linked to each other by means of lines with an aggregation factor. More information on this novel format can be found at (Casier 2013). The equipment model used in this simplified business model is shown in Figure 2.

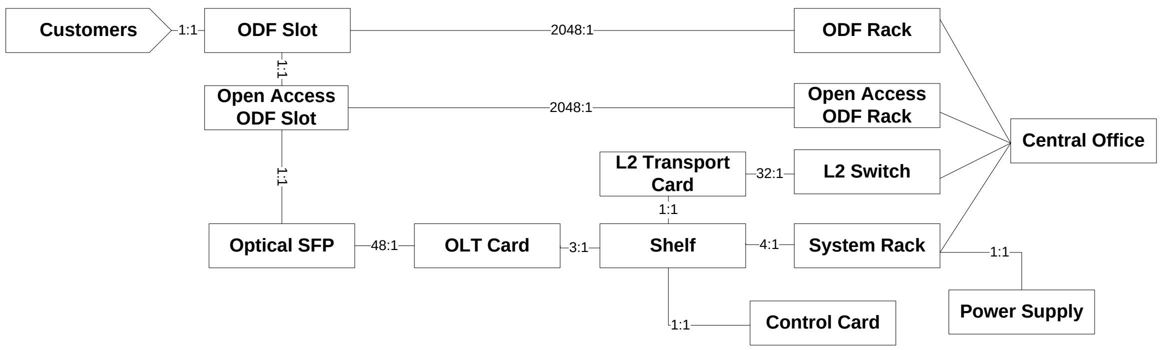

Figure 1: Equipment Coupling Modeling Notation for an open access central office infrastructure and network installation.

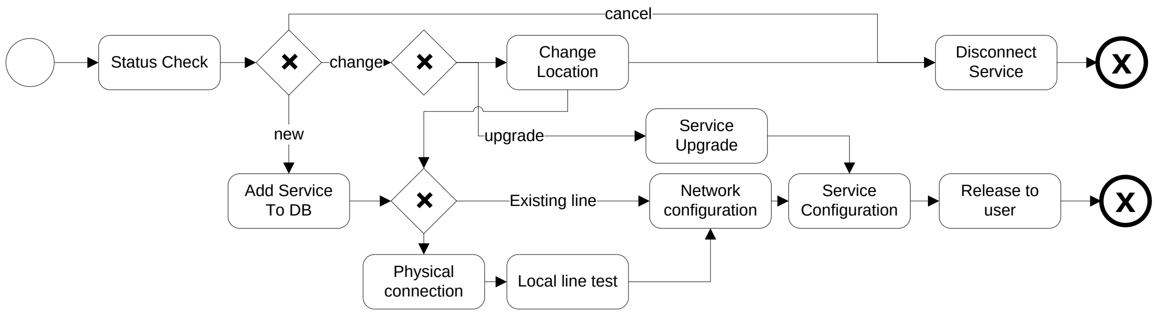

Figure 2: Business Process Modeling Notation for the operational process of customer provisioning

3.3 Operational Modeling

Operational modeling is based on the standardized Business Process Modeling Notation (BPMN) (OMG 2013) restricted to a smaller subset only containing the main flowchart structures required for cost calculation. Using an approach based on activity based costing (Kaplan 2004) and described in (Casier 2009), the costs can be linked to the execution of the process for a given planning horizon. The model for customer connection used in the case of an open access FTTH network is shown in Figure 3

3.4 Revenue Modeling

Once the full network, the equipment and the operational expenditures are modeled, all costs of the business model can be calculated. Still, this is only part of the analysis and should be complemented with a modeling of the revenues for each activity in the business model. The revenue modeling is aiming to calculate the revenues based on the costs and the number of paying customers. As such it has a notion of a fixed revenue scheme but also of an adaptive scheme aiming at break-even or a profit over break-even with an adjustable timing on when to get up to this point. Additionally the revenue model allows switching between revenue schemes at a given time or condition (e.g. critical customer mass reached). This revenue modeling allows answering questions on the main economic indicators such as profitability, minimal and advised pricing or payback period. A more formal specification of the full model is given in (Casier 2013). The models used in pricing the open access and the final connection price are kept deliberately very simple, where we assume each role to aim for 20% profit over a planning horizon of 10 years. Deploying the physical infrastructure of the network will make an exception to this and aim for 10% profit over a planning horizon of 20 years.

4 MULTI-LEVEL MODELING

The multi-level modeling links the cost and revenue models to the respective higher level elements, activities and monetary flows in the business model. A cost estimation model is attached to each activity in the business model actually leading to costs in its execution. A revenue model is attached to each monetary flow between two activities. Finally, additional input (e.g. amount of customers or price of equipment) can be defined as time-dependent values and linked to the models of the activities. Once all inputs are defined, all activities causing costs and all monetary flows are linked to a cost, respectively a revenue model; the business model can be fully simulated.

The calculation starts from the activities of the graph which have no outgoing monetary value exchanges, or in other words, which use no service from a lower level activity for which they are charged. The costs in these blocks can be fully calculated using their internally attached cost model. In the case of **Error! Reference source not found.** the cost for the physical infrastructure can readily be calculated. When this cost is known together with the expected amount of customers, executions, etc., this should be charged to the revenue model and linked to the monetary incoming arrow(s) to be able to calculate pricing and total revenues. Again in **Error! Reference source not found.** the amount the PIP will charge to the NP for the use of its infrastructure can now be calculated. The same calculation steps can be taken for connecting the customers and the price charged for this role to the NP. At this point the network provisioning is becoming the next point in the calculation, as all outgoing value exchanges linked to this activity are fully quantified. And finally this allows calculating the price to charge to the end customer. This recursive scheme allows all activities and monetary flows in any business model to be fully quantified.

We translated Figure 1 into a business model configuration that can be simulated by attaching the infrastructure cost model to the physical infrastructure deployment role, linking the equipment model for the active equipment to the network deployment role and finally operational model to the network provisioning role. We assume all monetary flows to aim for 20% profit on the costs of the role (and underlying roles). As mentioned the infrastructure considers only 10% profit. Additional information can be exchanged between models, as for instance the amount of installed equipment will be the driving value for operational maintenance.

When calculating the business model for the given scenario, the different cost components are calculated in terms of the amount of customers in the area (physical infrastructure) and the amount of customers to connect to the network. The first is equal to the amount of inhabitants in Ghent and for the second, we consider a bass adoption curve with as market potential 95%, with innovation (p) 0.03 and imitation (q) 0.38. A demand aggregation of 30% is expected as a boundary condition for the FTTH network deployment. All costs of the physical infrastructure and network provider are discounted with a discount factor of 5% respectively 10%.

Figure 4 gives the results for the cumulative discounted costs, revenues and outcome for the 10 years for (top) the PIP infrastructure, (middle) the PIP operational expenditures and (bottom) the overall NP outcome.

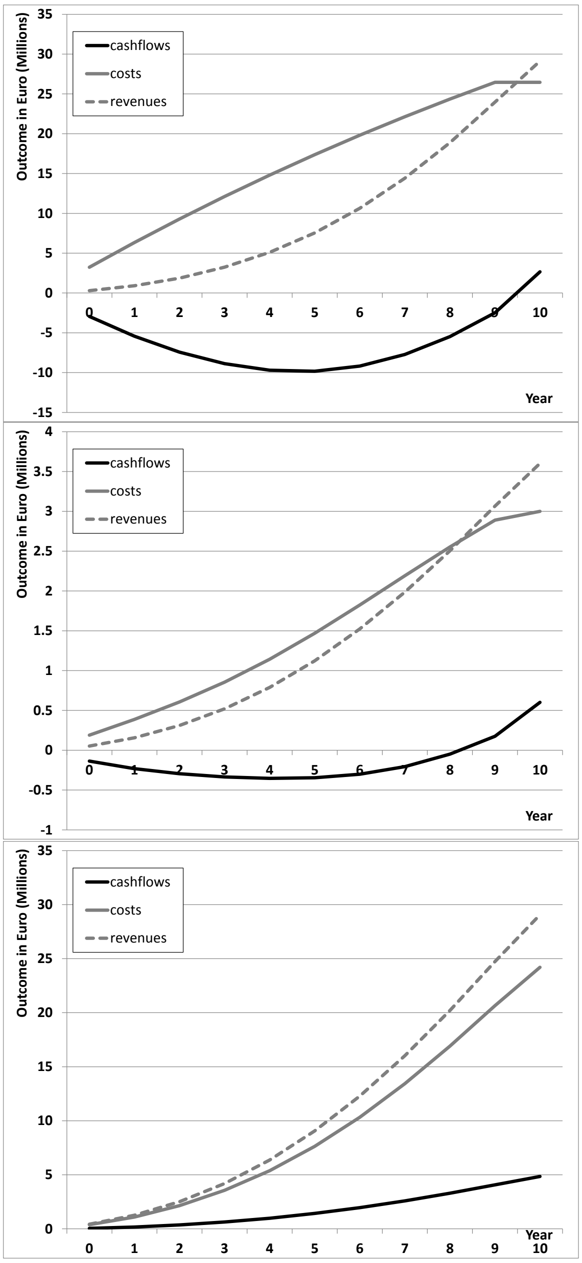

Figure 3: Overview of the costs, revenues and profit for the different roles in the open access business case

In this business case the PIP will have to charge a price of €235 per customer per year to the NP for the use of its infrastructure and a price of €42 for making a connection to a customer. This already incorporates the fact that customers will only need a one-time physical connection and changing providers afterwards does not require dispatching an installation team. This leads to an overall cost of €277 per customer per year charged from the PIP to the NP, which is equal to a monthly price of €23 (€19.5 for the infrastructure)

The NP will additionally provide the necessary equipment and make a contract with the PIP. In order to accomplish this, the NP needs to charge the customer a yearly fee of €339 or a monthly fee of approximately €28.

4 CONCLUSIONS & FUTURE WORK

Building a viable business case for a commercial offering based on novel technology on the market is not straightforward; especially in case different actors have to cooperate. Estimating the viability of such business cases requires input and knowledge from two research fields – (1) techno-economic research in which cost simulation models are built and (2) business modeling in which graphical models are focusing on the roles, actors and their interactions. A combination of both requires a multi-level business modeling approach in which a graphical business model is linked to separate techno-economic simulations. Clearly this will require an intuitive and complete business modeling ontology in combination with domain specific techno-economic cost as well as revenue simulation languages.

In this paper we have presented a multi-level business modeling approach – called BEMES – with a very intuitive yet complete business modeling ontology and linked (in an extensible manner) to network infrastructure, business process and a novel equipment modeling as well as to a (also novel) revenue modeling. We have used this approach to build a business model for an open access FTTH network deployment in which a physical infrastructure provider is leasing the fibers to a network provider together with the operations for connecting customers. Both actors will aim for a profit of 10% (infrastructure) respectively 20% (network). This business model configuration clearly shows the value of BEMES as the viability of the overall business case can be quickly checked against the final subscription price that needs to be charged to the customers. In this way we learn that an open access deployment in the city center of Ghent should demand at least €28 for providing FTTH connectivity to the end customer.

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REFERENCES

Al-Debei, Mutaz M., Avison D.. "Developing a unified framework of the business model concept." European Journal of Information Systems 19.3 (2010): 359-376

Analysys Mason, "Final report for the Broadband Stakeholder Group: The costs of deploying fibre-based next-generation broadband infrastructure", Ref: 12726-371 (8 September 2008).

Banerjee A. and Sirbu M., "Towards Technologically and Competitively Neutral Fiber to the Home (FttH) Infrastructure," in Proceedings of The 31st Research Conference on Communication, Information and Internet Policy, Washington DC, USA (19-21 September 2003).

Casier K.,, Techno-Economic Evaluation of a Next Generation Access Network Deployment in a Competitive Setting, PhD degree at the Faculty of Engineering of the Ghent University obtained, October 8th 2009

Casier K., Revenue Modeling Wizard Specification, 2013, http://forge.fi-ware.eu/plugins/mediawiki/wiki /fiware/index.php/FIWARE.OpenSpecification.Apps. BusinessCalculator.Revenue

Casier K., The Equipment Coupling Modeling Notation (ECMN) Specification, 2013, http://forge.fi-ware.eu/plugins/mediawiki/wiki/fiware/index.php/ FIWARE.OpenSpecification.Apps.BusinessCalculator .ECMN

Chesbrough, H. W. "Open innovation : the new imperative for creating and profiting from technology" Boston, Mass.: Harvard Business School Press., 2005

Coenen, T., De Waele L., Ballon P.. "The Simbu method-Supporting creativity in business modelling for open innovation" 2009

Coenen, T., Ranaivoson, H., Ballon, P. "Tool support for the Open Business Model Innovation funnel". Proceedings of ISPIM Innovation Symposium 2010, Quebec, Canada.

Gent, Gent in Cijfers, Online information on the city of Ghent (Dutch), http://gent.buurtmonitor.be/

Gordijn, J., De Leenheer P., and Razo-Zapata I. "Generating Service Value Webs by Hierarchical Configuration: A Case in Intellectual Property Rights Clearing." System Sciences (HICSS), 2011 44th Hawaii International Conference on. IEEE, 2011

Kaplan R.S., Anderson S.: "Time–Driven Activity-Based Costing," Harvard Business Review, 2004, vol. 82, no. 11, pp. 131-138.

Konnertz, L, Rohrbeck R., and Knab S. "How collaborative business modeling can be used to jointly explore sustainability innovations."ISPIM Annual Conference, Hamburg, Germany. 2011.

Medcalf R., Mitchell S., "Fiber to the Home: Technology Wars", http://www.cisco.com/web/about/ac79/docs/wp/Tech_Wars_Part__1_Ext_EI_0128.pdf (January 2008).

Mitcsenkov A., et al., Geometric versus Geographic Models for the Estimation of an FTTH Deployment, Telecom Systems Journal special issue, May 2016 (accepted)

Object Management Group/Business Process Management Initiative, http://www.bpmn.org/

Ostenwalder A., Pigneur Y., Tucci C.L., Clarifying Business Models: Origins, Present, and Future of the Concept, Communications of AIS, Volume 15, Article 1, 2005

Osterwalder, A. & Pigneur, Y., 2010. Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Hoboken, New Jersey: John Wiley & Sons

Pijpers V. • De Leenheer P., • Gordijn J.,• Akkermans H., Using conceptual models to explore business-ICT alignment in networked value constellations, Requirements Engineering (13 October 2011), pp. 1-24

Van der Wee M., et al., A modular and hierarchically structured techno-economic model for FTTH deployments. Comparison of technology and equipment placement as function of population density and number of flexibility points, ONDM 2012

Weiner N, Weisbecker A. "A Business Model Framework for the Design and Evaluation of Business Models in the Internet of Services." SRII Global Conference (SRII), 2011 Annual. IEEE, 2011