Forecasting FTTH as a New Broadband Technology

Valentina Radojicic[1], Goran Markovic[2] and Vladanka Acimovic-Raspopovic[3]

Abstract – **This paper proposes a model for FTTH forecasting as a new broadband technology. Our analysis is performed by using the Generalized Bass Model. We analyzed several possible scenarios with different percents of price reduction and marketing efforts as well as market potential. Based on the appropriate scenario it is possible to choose the best investment strategy.**

Keywords – **broadband traffic, forecasting, FTTH, transport network.**

I. INTRODUCTION

Huge investments have been made to roll out broadband networks in recent years. Long-term broadband demand forecasts have been and are crucial for investment decisions, rollouts and dimensioning of networks. Nowadays, the main broadband access technologies include DSL (Digital Subscribe Line) and Cable modem (Hybrid Fibre Coax). Other technologies like fiber and fixed wireless access are also entering the market. Especially in Japan, Hong Kong, China, and Korea, the growth of FTTH (Fiber-to-the-Home) has been significant in the last years [1]. There are several of technical, economic and business parameters that impact the right choice for each specific network situation. An operator runs the risk of picking an incorrect technology strategy if any of these key parameters are not identified and cost optimized [2]. Different technology options are available to operators today for their FTTH network deployment strategy decisions. Gigabit-Passive Optical Network (GPON), Ethernet Passive Optical Network (EPON) are called Point to Multi Point (P2M), Active Ethernet (AE) also known as Point-to-Point Ethernet (P2P) are the major competing technologies. Choice of active or passive architectures for deployment depends on the type of services to be delivered, cost of the infrastructure, current infrastructure and future plans for migrating to the new technologies.

With the aim of adequately planning required network resources, it is necessary to forecast traffic demands that are in direct correlation to the forecasted number of the customers. In this paper, we present a model for FTTH forecasting as a new broadband technology. The analysis made is based on diffusion theory, which takes into account advertising investment and effects of different prices. The Generalized Bass Model or GBM [3] has become especially popular, in both descriptive and normative applications. It is shown that in the GBM, the optimal evolution of advertising expenditures after launch is highly dependent on the initial level of advertising [4].

The paper is organized as followed. In the second section we present the various FTTH architectures available for deployment and worldwide forecasting of FTTH technology. The third section explains the GBM diffusion model that we used to forecast the future broadband demands. After that in the fourth section, we present the forecasted results for FTTH demand for Serbian market. Finally, we conclude the article giving the managerial implications.

II. FTTH ARCHITECTURES AND WORLDWIDE MARKET FORECAST

Network operators around the world are looking at transforming into Next-Generation-Network to remain competitive in a radically changing telecommunications environment. Broadband services continue its explosion, with the migration from copper broadband via xDSL to next generation FTTH deployments having begun in earnest. Optical fiber, as used in the core or metro network, can also be used in the access network as medium for digital transmission. Optical fiber can offer much higher bandwidths than are attainable with DSL or HFC [5]. The bandwidths that can be offered are largely depending on the fiber and architecture installed and the equipment used. In general fiber already runs up to a location close to the customer, and the different alternatives are indicated by FTTx with a specific character indicating where the fiber stops. Often used acronyms are FTTN (Fiber to the Node), FTTC (Fiber to the Curb) and FTTB (Fiber to the Building) with an ever advancing fiber running respectively up to the node, cabinet or building. The remainder of the access network is in these cases still bridged by DSL, HFC or wireless technologies. In the case the fiber runs all the way up to the customer's house, apartment or premises, this is called FTTH or FTTP.

FTTH Worldwide Market & Technology Forecast, 2006-2011 describes the key competing technologies, divided into two main categories – active fiber architectures, typically active Ethernet usually known as active optical networks (AONs), and passive fiber architectures, usually known as passive optical networks (PONs). The optical network termination (ONT) at the customer side performs the translation of the optical signal to the in-house wiring. Next to Ethernet it is not uncommon to perform a translation to a broad range of existing connectors at this point (coax, twisted pair, wireless). The inside optical wiring is connected to the outside plant by means of an optical connector plug often referred to as the optical network termination point (ONTP). The structure of an FTTH network is shown in Fig.1.

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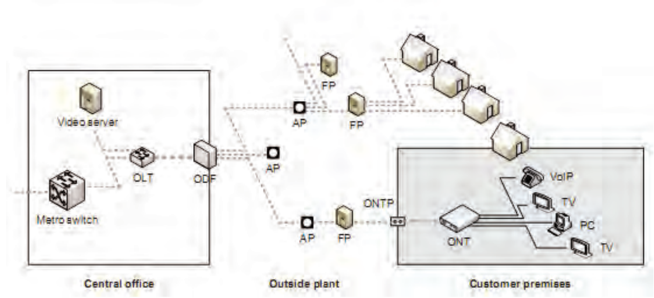

Fig. 1 Structure of FTTH network (OLT-optical line terminal; ONT-optical network termination; ODF- Optical Distribution Frame; FP-flexibility point; AP-aggregation points;)[7]

The optical signal is transported over the outside plant up to the central office. In the outside plant there are different aggregation points (AP) and often there is also a flexibility point (FP) comparable to a street cabinet in copper based networks, closest to the customer. At this point there are various options for the telecom operator. Passive optical networks (PONs) will aggregate the optical signal of different fibres into one fiber at such aggregation points using passive optical splitters and as such create a point to multipoint network with the optical fiber as shared medium. Active optical networks (AONs) will connect the customer with a dedicated fiber up to the OLT. Also the number of customers per PON, AP and FP are degrees of freedom for the operator installing the network. At the central office, all optical fibres connect to the ODF and from there to the optical line terminal which will aggregate all traffic, and translate between protocols where necessary. In case of a PON, access to the shared medium is divided between the different customers by means of some division multiplexing based protocol. At this point one or more additional wavelength(s) can be used for broadcasting content (for instance RF video) to all customers of a PON. Beyond the OLT, the traffic is sent into the metro network [7].

PONs became a popular solution among operators because they are seen as the least costly architecture for delivering FTTH in a mass market residential scenario. As one would expect, the initial population density developments were set in locations that maximize economies of scale, namely urban centres with high population density. The objectives of PON deployments are usually measured in Households Passed (HHP). In this context, a house is deemed as “passed”, when the distribution fiber reaches a Network Access Point (NAP) which, in urban settings, is usually placed inside buildings. The number of fibres that feed a given building is usually a function of the number of dwelling units in that building as well as of the Take Rate considered by each operator. The Take Rate is the predicted maximum percentage of users that will request the fiber service from the operator. Naturally this varies between operators and the type of areas served.

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Traditionally, the deployment of new telecommunications services/technology has taken years of effort and large amounts of investment. Thus, being able to predict the market acceptance before taking the business risk is critically important.

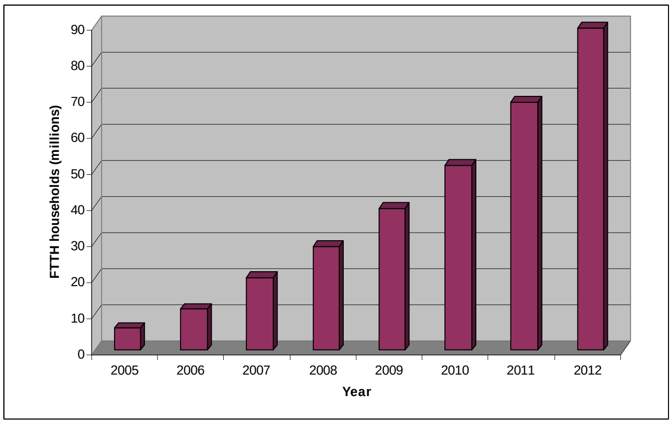

Fig. 2. Worldwide forecasting of FTTH technology [8]

Fig. 2. shows that the FTTH connected households will reach up to 90 million by the end of 2012.

III. Implementation of the GBM (Generalized Bass Model)

According to diffusion theory, a new service's sales growth at any time largely depends on the strength of word of mouth from its previous adopters. The most important model in this stream of research is the Bass model [9][10]. The Bass diffusion model has been widely used as forecasting procedure of new services/technologies and it was proposed to deal with the problem of initial adopters.

The mathematical structure of the Bass model is derived from a hazard function corresponding to the conditional probability that an adoption will occur at time *t* given that it has not occurred yet. If *f(t)* is the density function of time to adoption and F(t) is the cumulative fraction of adopters at *t*, the basic hazard function underlying the Bass model is given by Eq. 1:

$$\frac{f(t)}{1-F(t)} = p + q \cdot F(t) \qquad (1)$$

This model has three key parameters: the parameter of innovation (*p*), the parameter of imitation (*q*) and the market potential (*m*). Parameter *q* reflects the influence of those users who have already adopted the new technology, while *p* captures the influence that is independent from the number of adopters. The sale at time *t* is $S(t) = m[F(t) - F(t-1)]$, where *m* refers to the market potential for the new technology. These parameters can be estimated using cumulative sales data.

Generalized Bass Model, GBM incorporates control variables into diffusion models such as price and advertising

[3]. These are two marketing mix instruments that should ideally be used in extended diffusion models with marketing effects. However, researchers and managers may frequently have information on only one of the two (e.g. price). The GBM presents a surprisingly simplified structure:

$$\frac{f(t)}{1-F(t)} = Z(t)\cdot[p + q\cdot F(t)],\ \ t \geq 0 \tag{2}$$

where:

$$Z(t) = 1 + \alpha\cdot\frac{P(t)-P(t-1)}{P(t-1)} + \beta\cdot\frac{A(t)-A(t-1)}{A(t-1)} \tag{3}$$

follows:

$$Z(t) = 1 + \alpha\cdot\Delta P + \beta\cdot\Delta A \tag{4}$$

where are:
F(t)=N(t)/m – the cumulative function of adoption for time *t*; *N(t)* – the cumulative sales; *m* – the market potential; *p* – the parameter of innovation (initial probability of adoption); *q* – the parameter of imitation (diffusion rate); *α* – the diffusion rate as a result of price decrease for 1%; *P(t)* – the current price; *β* – the diffusion rate as a result of increase advertising for 1%; *A(t)* – the current level of advertising expenditure; Δ*P* – the proportional change in price; Δ*A* – the proportional change in advertising efforts.

Assuming F(0)=0, the closed-form solution of differential Eq. (2) is:

$$F(t) = \frac{\left(1 - e^{-Z(t)(p+q)t}\right)}{\left(1 + \frac{q}{p}e^{-Z(t)(p+q)t}\right)} \tag{5}$$

Note, the speed of adoption at a particular point in time is affected not by the level of price or advertising at that time but by the proportional change in those marketing mix variables at that time. If the percentage changes in price and advertising remain the same from one period to the next, then function Z(t) reduces to a constant, yielding again the Bass model. The GBM allows to test the effect of marketing mix strategies on diffusion and to make scenario simulations based on intervention function modulation. Function Z(t) acts on the natural shape of diffusion, modifying its temporal structure and not the value of its internal parameters: as a consequence, the important effect of Z(t) is to anticipate or delay adoptions, but not to increase or decrease them. In other words, function Z(t) may represent all those strategies applied to control the timing of a diffusion process, but not its size [11].

Estimation of the parameters *p*, *q* and *m* is required to identify the diffusion curve. Bass model could be used to predict the timing and magnitude of the sales peak, and the shape of the diffusion curve. But, the most applications of the Bass model are used to make plans and decisions before the service/technology has been introduced to the market. Usually, no sales data exists with which to estimate *p* or *q*. Manager has not an intuitive estimate of *p* and *q*. In such a case, Bass parameters could be evaluated in two manners. One way is to use analogies with other similar services or diffusion process. The second way is analytical using comparative procedure with some other countries where a service/technology already exists.

If data sales does not exist, the market potential has to be estimated by taking into account different impact factors such as economy and social development of a particular area, presence of competitive broadband technologies, operators infrastructure investment strategies, etc.

IV. NUMERICAL RESULTS FOR SERBIAN MARKET

The users will be the focus of the operator and the estimation of their adoption behavior is probably the most important source of input for a planning activity and business model. Serbian broadband market is characterized by three long-standing market technologies: ADSL (Asymmetric Digital Subscriber Line), HFC (Hybrid Fiber-Coax), FWB (Fixed Wireless Broadband). However, it is expected that FTTH technology will be introduced this year. In this paper, we considered GBM as input model for our research.

We analyzed here several possible scenarios related with the cost for end users and marketing efforts. The cost of FTTH per home will be related with the chosen type of fiber architecture and cost of installation. For example, the cost of ONT in a PON will be higher (about 40%) than in case of an HRN (Home Run Network). We assumed this price difference because an HRN poses less stringent requirements considering the optical budget, bandwidth and protocol. In a case of an all buried network, the fiber cable to be installed for bridging the last meters is already available and connected in the pedestal. As such the trenching at installation time is minimized. In a case of an aerial customer connection, the last meters from the drop box up to the house have to be bridged at installation time. This difference leads to a less costly installation in case of an all buried network.

Here we proposed seven possible *Scenarios*. The Bass parameters, *p* and *q*, are estimated by comparative procedure based on worldwide forecasting of FTTH technology, using ordinary least squares (OLS) multiple regression by Eg. 6 - 8. In all proposed *Scenarios* the parameter of innovation are remaining unchanged.

In all considered *Scenarios* we assume that the substitution effects will happen between new (FTTH) and current technologies (HFC, ADSL, and FWB). It means, that overall market potential in Serbia, which is estimated to *m*=2.500.000 households, will be reduces in a case of FTTH to 500.000 (alternatively 800.000) households, because of low households economy and necessary investments in network infrastructure. In *Scenario 1* there is no change in price and marketing efforts. It corresponds to basic Bass model. All other Scenarios are compared with it. *Scenario 2*, *3* and *4* assume that the cost will be reduced for 20%, 40% and 60% respectively. The price reduction will make influence on the increasing of the parameter of imitation as we assumed in Table I. In addition, the price reduction could have an impact on market growth (*Scenario 4*). *Scenario 5, 6* and *7* take into account marketing mix variables (price and advertising). Estimated parameters values for considered *Scenarios* are given in Table 1.

TABLE I
ESTIMATED PARAMETERS

Scenario	*p*	*q*	*m*	Δ*P*	*A*	Δ*A*	*β*
1	0.001	0.12	500.000	0	-0.37	0	/
2	0.001	0.25	500.000	-0.2	-0.37	0	/
3	0.001	0.29	500.000	-0.4	-0.37	0	/
4	0.001	0.29	800.000	-0.6	-0.37	0	/
5	0.001	0.25	500.000	-0.2	-0.37	0.4	0.35
6	0.001	0.29	500.000	-0.4	-0.37	0.6	0.35
7	0.001	0.29	800.000	-0.6	-0.37	0.8	0.35

The obtained results for proposed Scenarios are given by Fig. 3 and Fig. 4.

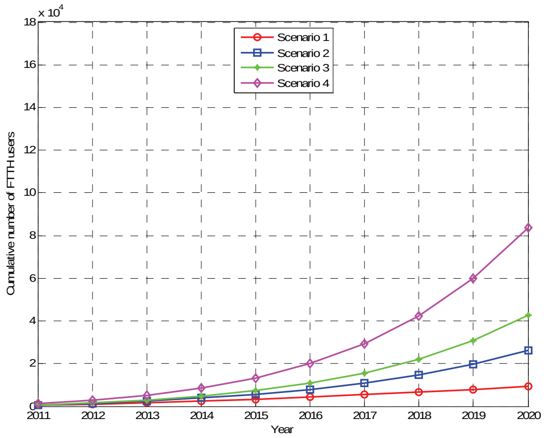

Fig. 3. Forecasted results for FTTH households for different percentage price reductions (20%, 40%, 60%)

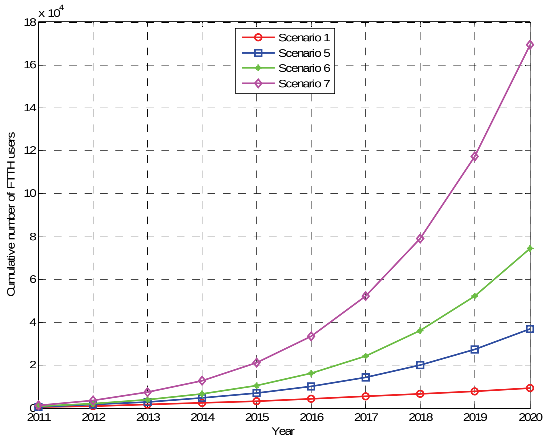

Fig. 4. Forecasted results for FTTH households for different percentage price reductions (20%, 40%, 60%) and advertising efforts (40%, 60%, 80%)

We can see that the cumulative number of FTTH users is heavily influenced by price reductions (Fig. 3) as well as advertising efforts (Fig. 4). For example, it is expected that the number of FTTH households in Serbia could reach up to 34.000 users in 2016, depending on the advertising investments and price reduction.

V. CONCLUSION

In this paper we suggest the GBM (Generalized Bass Model) for long-term forecasting of new broadband technology. The main advantage of this model is that it includes the marketing mix variables: price and advertising effects. It enables broadband operators to predict the number of users according to the price reductions as well as marketing investments. Also, the proposed model would enable operators to quickly make the right technology deployment decisions. We applied this model for FTTH technology deployment in the case of Serbian market. We analyzed several scenarios with different percents of price reduction and marketing efforts as well as market potential. In this way, managers can make the right technology investments and cost strategies that are important to capture new broadband market shares.

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