ABSTRACT

The paper discusses the approach to formative and summative evaluation of alternative solutions for next generation optical access network. Unlike most of the old approaches to planning of network facilities, we adapt the new paradigm where teletraffic engineering and service management interact at different levels of systems description. The basic thesis is that formative traffic evaluation has to be the key part of initial and ongoing project activities in deploying new technological solutions in urban telecommunications network. Passive Optical Network (PON) is analysed as one effective solution because it satisfies the broadband traffic requirements with minimal amount of optical equipment and fiber deployment. Free-space optical wireless network is marked as new flexible solution for bridging gaps in broadband servicing.

KEY WORDS

telecommunications, evaluation, traffic, access, optical network

1. INTRODUCTION

New technical solutions in access network and liberalisation of telecommunication service provision open new questions about effective design and exploitation of access network which accounts for about 50% of the total investment in telecommunication networks. In addition to public copper-based telephone network and cable-TV (CATV) networks, optical fiber and radio access technology become competitive alternatives thanks to a favourable price trend.
Basic steps in doing project evaluation are:
— define purpose of evaluation,
— define measurable outcomes of projects and risks,
— evaluation design (methods, instruments, etc.),
— collect data and information,
— analyse data and information,
— provide findings to decision-makers.

Future access network will normally consist of a fibre-based system from the local exchange up to a concentration or multiplexing point relatively close to the subscriber. The last section will have a system based on paired copper cable, coaxial cable or radio. Alternative solutions include fibre optic all the way to subscriber, i.e.:
— FTHH (fibre to the home) solution,
— FTTO (fibre to the office) solution.

Fibre-optic systems become first choice in the sections next to the local exchange where network carries large volumes of teletraffic. This section is designed as a ring-shaped and/or metropolitan transport network can be arranged in a ring structure with protection switching as illustrated in Fig. 2. Traffic is routed from the subscriber side to add/drop multiplexer (ADM). In the case of ring breaking, the traffic will be reversed so that none of it will be lost.
3. TELETRAFFIC ANALYSIS AND FUNCTIONAL REQUIREMENTS

Formative evaluation of telecom network projects have to begin through the initial phase of the project and it must be done at several points in the development phase of the network facilities life cycle. Teletraffic analyses which include the existing and the new users and functional requirements is necessary for effective formative evaluation of network resources in urban/metropolitan area.

Beyond the standardised technical solutions at the physical and logical layers, there is a large amount of systems engineering works that must be done to develop effective solutions. Teletraffic engineering and service management can be considered as the basic ingredients of holistic telecommunication network development and deployment. Basic framework for analysing network resource provisioning cycle is given in Figure 3.

Traffic demand can be forecast from historical data and/or from service providers’ expectations. Based on the forecast traffic demand \((p,s,t)\) for defined population, space and time as backdrop variables*, the access network can be appropriately dimensioned by the TE functions in terms of network configurations, capacity and quality of service (QoS) parameters. This new approach is introduced and elaborated in teletraffic technology textbooks [2]. The basic mappings are:

\[
\begin{align*}
\phi_{jk} & \rightarrow \phi_i \\
\phi_i & \rightarrow \text{TM}
\end{align*}
\]

where: \(\phi_{jk}\) denote traffic demand between nodes \(j\) and \(k\) 
\(\phi_i\) denote traffic flows on link \(i\) 
\(\text{TM}\) denotes traffic matrix.

4. EVALUATION OF OPTICAL ACCESS NETWORK ALTERNATIVES

During the long period 1980-2000, the technological development of access network was slow compared with rapid development of backbone network. The growth of Internet traffic has actuated the problem of the local loop or “last mile” as a bottleneck for broadband teletraffic requirements. In most cases digital subscriber line (DSL) cannot be an effective solution because service providers do not provide DSL services to subscribers located more than a few kilometers from the local exchange.

Optical fiber is capable of delivering broadband services at distances beyond 20 km in the subscriber access network. A point-to-point (P2P) topology with dedicated fiber runs from the LE to each end-user subscriber is simple but cost prohibitive solution. It requires significant fiber deployment as well as connector termination space in the local exchange. We can calculate that for \(N\) subscribers at an average distance \(L\ [\text{km}]\) from the LE, a point-to-point solution requires:

- 2 \(N\) transceivers
- \(N\ (L\ [\text{km}]\) total fiber length.

Another solution with a remote concentrator (switch) close to the neighbourhood reduces fiber deployment but increases the number of transceivers to:

- \(2N + 2\) transceivers.

A curb-switched architecture also requires electrical power as well as backup power at the curb unit.

Next possible solution is to replace the active curb-side switch with a simple and inexpensive passive optical component. These “passive optical network”

\[
\begin{align*}
\text{Network subscribers} & \rightarrow \text{Teletraffic forecast} & \text{Teletraffic matrix} \\
\text{Access Control} & \rightarrow \text{Network Resource Availability Matrix} & \text{Network dimensioning} \\
\text{Services Management (SM)} & \rightarrow \text{Teletraffic Engineering (TE)}
\end{align*}
\]
(PON) solutions minimize the amount of optical transceivers, LE terminations and fiber deployment. Access network based on single fiber PON only requires:
— N + 1 transceivers
— L [km] of fiber.

Comparative analysis of the discussed access network solutions for example with \( N = 128 \) end-nodes is given in Figure 4.

5. PASSIVE OPTICAL NETWORK

A passive optical network (PON) with appropriate point-to-multipoint topology can be an effective solution for the access network with broadband traffic requirements because it minimises the amount of optical transceivers, LE terminators and fiber deployment (as described in section 4). In practice, there are several possible PON topologies. Some of them are illustrated in Fig. 5.

a) P2P network: 128 fibers
\( 2 \cdot 128 = 256 \) transceivers

b) Curb-switched network: 1 fiber
\( 2 \cdot 128 + 2 = 258 \) transceivers

Figure 4 - Comparative solutions of optical access network

Figure 5 - Alternative PON topologies

PONs can be deployed in any of the depicted topologies using 1:2 optical top couplers or 1:N optical splitters. All access transmissions in PON are performed between an optical line terminal (OLT) and optical network units (ONUs). The OLT is installed in the local exchange. The ONU is located at either the curb (FTTC solution) or the end-user location (FTTH and FTTB).

6. CONCLUSION

Effective planning and deployment of next-generation optical access networks in urban areas require new holistic approach and formative evaluations where teletraffic analysis must be considered as the basic ingredient. In this paper the approach to formative evaluation is discussed and the basic framework for analysing access network resource is given.

Passive optical network (PON) with several suitable multipoint technologies are suggested as possible effective solutions for the next-generation access network. Standardisation initiatives related to PON-based optical access network started with ITU Recommendation G.983 which define PON that uses asynchronous transfer modes (ATM). Because Ethernet technology is widely accepted in metropolitan area networks (MANs) for connecting LANs, there are special interests for comparative evaluation of Ethernet and ATM solutions. Future research and methodological support for holistic evaluation of telecommunication network projects are necessary.

Free-space optical wireless technology has to be considered as a new solution to the “first mile” problem, especially in densely populated urban areas.

SAŽETAK:

6. CONCLUSION

Effective planning and deployment of next-generation optical access networks in urban areas require new holistic approach and formative evaluations where teletraffic analysis must be considered as the basic ingredient. In this paper the approach to formative evaluation is discussed and the basic framework for analysing access network resource is given.

Passive optical network (PON) with several suitable multipoint technologies are suggested as possible effective solutions for the next-generation access network. Standardisation initiatives related to PON-based optical access network started with ITU Recommendation G.983 which define PON that uses asynchronous transfer modes (ATM). Because Ethernet technology is widely accepted in metropolitan area networks (MANs) for connecting LANs, there are special interests for comparative evaluation of Ethernet and ATM solutions. Future research and methodological support for holistic evaluation of telecommunication network projects are necessary. Free-space optical wireless technology has to be considered as a new solution to the “first mile” problem, especially in densely populated urban areas.

LITERATURE:


