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WĄBRZEŹNO CITY BROADBAND IP NETWORK

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Summary: In the paper the designing project (plan) of Wąbrzeźno City broadband IP optical network has been presented. The extended version of network plan constitute technical part of network Feasibility Study, that will be implemented in Wąbrzeźno and be financed from European Regional Development Funds. The network plan presented in the paper contains both topological structure of fiber optic network as well as the active equipment for the network. In the project described in the paper it has been suggested to use Modular Cable System – MCS for passive infrastructure and Metro Ethernet technology for active equipment. The presented solution provides low cost of construction (CAPEX), ease of implementation of the network and low operating cost (OPEX). Moreover the parameters of installed Metro Ethernet switches in the network guarantee the scalability of the network for at least 10 years.

Keywords: broadband, IP network, active infrastructure, passive infrastructure, backbone network, access network.

1. INTRODUCTION

Modern networks based on IP protocol are not currently used only for browsing websites and transfer information to global Internet, as it used to be in the initial stage of IP network development, but are also used as an efficient communications systems transferring different types of signals, including audio and video. Therefore, when designing (planning) a broadband IP network of Wąbrzeźno City, the network structure that have been considered then, should be opened for new users services and traffic volume growth during the next few years. When designing a network, it is essential to define very particular optimization problem. In his paper Richard van Slyke [8] has classified potential network design problem according to the list presented in table 1.

Table 1. List of potential network design problems.

	Given	Determine	Objective
1.	Traffic requirements, network topology, routing of traffic	Capacity of network transmission channels	Optimize tradeoff between channel costs and network performance
2.	Traffic requirements, network topology, capacity of network transmission channels	Routing of traffic in network	Minimize traffic delay
3.	Traffic requirements, network topology	Capacity of network transmission channels, routing of network traffic	Optimize tradeoff between channel costs and network performance
4.	**Traffic requirements**	**Network topology, routing of traffic, capacity of network transmission channels**	**Optimize tradeoff between channel costs, network performance and reliability**
5.	Terminal locations, traffic requirements	Location of multiplexers, concentrators, and/or routers	Minimize channel costs
6.	Terminal locations, traffic requirements, location of multiplexers, concentrators, and/or routers	Assignment of terminals to multiplexers, concentrators, and/or routers	Minimize channel costs

The Wąbrzeźno City broadband IP network required to be designed as a completely new network, both in passive and active network parts, so according to the table 1 it is defined as No 4 problem. In that case, when a completely new network is planned, the major task, is to find a compromise solution which comply several aspects impacting on the investment network cost (CAPEX), operating costs (OPEX), as well as users revenue. The aspects that should be taken into consideration during network planning process includes [8]:

1. The definition of all current and future services which planned network will offer and the classes of users for those services;
2. The designation of traffic volume generated by internet users located in areas served by the network;
3. The designation of expected level of the planned network scalability;
4. The designation of the proposed network topology, that depends on the geographic range of the area in which the network is implemented;
5. The designation of the level of network reliability, measured by network availability;
6. The definition of the network security level, including in particular secure access to active network resources;
7. The designation of maximal acceptable level of capex and opex costs for planned network guaranteeing fulfilling others network aspects defined above.

In fact, designing Wąbrzeźno City IP network, only some of mention above aspects have been considered. The aspects considered during Wąbrzeźno City network planning process are listed below:

- designed network should connect defined locations in Wąbrzeźno City;
- traffic generated from the locations should be transferring toward (from) global Internet;

- the locations should be connected with the use of fibers cables;
- in every location an active equipment (Ethernet switch or IP router), should be installed for generated traffic transfer,
- implemented network should minimize the total investment cost (CAPEX and OPEX costs);
- planned network structure should maximize network reliability;
- network should be scalable in time period not shorter than 10 years.

Taking under consideration the defined above network planning aspects, it is possible to formulate the optimization network designing problem, as follows. Design new network that:

1. minimize total investment cost;
2. maximize the network reliability;
3. maximize total network performance (i.e. throughput);
4. active equipment installed in the network should fulfill scalability for at least 10 years of its life.

As, defined above, optimization problem is very difficult for solving, so it has been reformulated as an optimization problem with constraints. The analyzed optimization problem for Wąbrzeźno City network, has been defined as follows:

– maximize the total network performance (throughput),
– under constraints:
    - the investment cost should not exceed defined value;
    - the network should operate in the proper way in the case even when one link or node will be damaged (defined network reliability level);
    - the active equipment should be scalable for at least 10 years.

When designing, completely new IP network, either on local (city) or on regional level, two key elements, that affect on the network structure and active equipment efficiency, should be considered. These key elements are:

1. <u>User expectations (demands) of access lines bandwidth growth ratio</u>. Nielsen law [7, 9] says that the users expectation of access line bandwidth grows exponentially, with the growth rate of about 50% every year by an average;
2. <u>The total traffic volume growth in the global ip network.</u> Based on cisco reports [2,3,4], it follows that the growth rate of traffic volume is exponential with cagr (compound annual growth rate), in period of the years from 2007 to 2012, of around 40%.

The backbone of Wąbrzeźno City Broadband IP Network has been planned using ring topology. The total throughput of the inner link between BN_1, BN_2 and BN_3 nodes is 10 Gb/s. The access nodes are connected to the backbone nodes on the basis of star topology. The total throughput of the access links is 1 Gb/s. Considering above the planned network keeps relatively high quality to price ratio.

The presented in this paper Wąbrzeźno City network plan constitute technical part of network Feasibility Study, that will be implemented in Wąbrzeźno and be financed in 75% from European Regional Development Funds.

2. SERVICES OF WĄBRZEŹNO CITY BROADBAND IP NETWORK

As it has been shown in the introductory section, one of important aspect affecting the overall network design is the range of services offered to network users. Modern IP networks offer services to any class of the users, i.e. for residential ones, for users required special needs (security or emergency ones), for local government units, for users that use telemedicine applications, for business users. Below the list of possible services in Wąbrzeźno City network is presented.

1. Services for residential users include:
   a) Internet access services;
   b) Peer-to-Peer services (P2P).
   c) additional services:
      i. VoIP telephony;
      ii. IP television;
      iii. Video on Demand;
      iv. local community portals;
      v. monitoring services;
   d) services offered to residential users by local government, i.e. e-government services for the citizens of the city, educational institutions, business;
   e) home office;
   f) teleeductation;
      i. e-learning: access to selected text and visual content, displayed on Internet portals, virtual language courses and e-learning;
      ii. e-school.

2. Services for users required special needs:
   a) central control of traffic lights to improve traffic in the city and the region as well as provide actual information about traffic
   b) dynamic information about departure times of public transport;
   c) certain municipal tasks telemetry;
   d) shared 112 number for communication in emergency situations;
   e) numbers for communication in undefined situations, such as 311 number in the U.S. or the 115 number in Germany;
   f) monitoring of selected areas of the city and schools based on digital cameras and IP video surveillance system;
   g) monitoring and surveillance of various alarms and monitoring center;
   h) Emergency Services Management Center;
   i) integration of emergency services in crisis situations.

3. Services for local government units:
   a) communication services ensuring save data transmission between local government units (LGUs) on the basis of VPN network;
   b) VoIP telephony communications among different LGU's;
   c) management of LGU's subordinate infrastructure (lighting, traffic lights etc.);
   d) public access to Internet, Internet kiosks and hotspots.

4. Services for business users:
   a) pictures of interesting sites of the city, transferring to global Internet;
   b) tourist information and accommodation infrastructure;
   c) Home Office;
   d) Teleworking;
   e) Video-conference, including telepresence;
   f) Corporate VPN's or VLAN's networks.

5. Telemedicine services:
   a) remote hospital consultations on special cases of the diseases;
   b) patients monitoring, and remote diagnostics, ie. telecardiology, teleradiology etc;
   c) teleconferences, including videoconferences and telepresence;
   d) access to patients data bases;
   e) VPN networks for communication among health units (i.e. hospitals).

For the above services listings, the following assumptions for access links has been considered:
a) group number 1 – 6 Mb/s symmetrical;
b) group number 2 – 20 Mb/s symmetrical;
c) group number 3 – 20 Mb/s symmetrical;
d) group number 4 – 6 Mb/s symmetrical;
e) group number 5 – 20 Mb/s symmetrical;

To define network topology, as well as to estimate necessary efficiency of an active equipment, installed in the designed network, it is needed to know the network nodes to which traffic, generated by various services, is directed. First of all, it is necessary to define whether the traffic is oriented towards other nodes installed in the planned network, or it is routed to Internet eXchange Point (IXP), that join the planned network with global Internet. The nodes to which traffic generated is directed in the regional or city (local) network are depicted in table 2.

Table 2. Service types and transfer direction of traffic generated by these services.

Type of service	**Transfer direction of traffic**	**Type of traffic**
Peer to Peer (P2P)	Global Internet (IXP)	Symmetrical
Video for PC, ie. YouTube, etc.	Partly – regional network, mainly global Internet (IXP)	Asymmetrical
IP TV, VoD	Servers in regional network	Asymmetrical
WWW	Global Internet (IXP)	Asymmetrical
Interactive games	Global Internet (IXP)	Symmetrical
Videoconference	Mainly – regional network	Symmetrical
VoIP	Mainly – regional network	Symmetrical
Data transmission – VPN	Mainly – regional network	Symmetrical
Monitoring	City network – within the area of distribution node	Asymmetrical
Telemedicine	Mainly – city and regional network	Symmetrical
Services for security	Mainly – city and regional network	Symmetrical

Cisco reports [2,3,4] show that the largest part of global traffic volume makes P2P traffic. Moreover, large parts of traffic volume make also video for PC, interactive games and WWW traffics. Table 2 shows that the significant part of entire traffic volume, generated in the city network is directed toward Internet eXchange Points (IXP), so planned Wąbrzeźno City network should be called, “traffic oriented network” [10]. “Traffic oriented network” is meant the network that has been implemented in the way ensuring transfer of largest part of entire traffic volume, via the shortest paths. For city or regional networks the optimal “traffic oriented network” structure is star topology with IXP as the root. As in fact, city network is usually considered as the network included in regional one, making access network of it, so from table 2 it follows, that the largest part of traffic volume generated in city network is oriented toward global Internet via regional network (IXP consists connection point between city network and regional one).

The total traffic volume directed to IXP, consist of Peer to Peer traffic, Web traffic, traffic for interactive games, video for PC’s traffic, all oriented towards global Internet, as well as video for TV traffic (such as IP TV, Video on Demand), videoconference traffic, Voice over IP traffic, e-health services and hospital applications traffic, all oriented towards regional network. As all this part of traffic are oriented to IXP, so the total volume of traffic transferred via IXP reaches more than 95% of entire one [2,3,4]. The only traffic that is oriented towards other nodes in Wąbrzeźno City network, is the traffic generated by monitoring systems installed in Wąbrzeźno.

Table 2 also shows the nature of the traffic transferred in city network in relation to a particular class of service. And so, the service, IP TV, VoD, video for PCs, generate asymmetric traffic, for which volume transmitted down the network, i.e. to the users, is much larger than the volume of the traffic directed up the network (to IXP). The traffic generated by monitoring systems is also, asymmetrical, but in difference to IP TV, Web, or video for PC traffic, the significant volume of this traffic is transferred from aggregation points (such as monitoring cameras) to the monitoring center, located locally, in the city.

The information contained in Table 2 will be used both, for determination of the traffic management way in Wąbrzeźno City network and for designation the optimal parameters of switching devices (i.e. Metro Ethernet switches or IP routers) installed in this network.

3. PASSIVE INFASTRUCTURE OF WĄBRZEŹNO CITY NETWORK

Topological structure of Wąbrzeźno City network passive fiber optic physical layer is shown in figure 1. This structure shows layout of all build, under the ongoing project, fiber optic cables, both for backbone and access network. In table 3 Wąbrzeźno City network node locations and characteristic of those nodes has been depicted. As the fibers are planned to be put along the road the length of the fibers has been calculated on the basis of google maps indications.

Fig. 1. Planned optical fiber routes for Wąbrzeźno City network.

Figure 2 in turns, shows a topology structure of network nodes and links connections between the nodes depicted in figure 1, that was created on the basis of fibers cable physical layout. The diagram presented in figure 2, has been used for a mapping of physical topology depicted in figure 1 into logical network topology shown in figure 4. In planned Wąbrzeźno City IP network it has been assumed that 3 nodes (BN_1, BN_2, BN_3) function as the distribution/aggregation nodes and the other ones as the access nodes.

Table 3. Node location and their characteristics.

No.	Node name	Node type	Location
1	Ampol	Access (A1)	Mikołaja z Ryńska st.
2	GPZ	Access (A2)	Matejki st.
3	Boiler	Access (A3)	Pruszyńskiego st.
4	Estate	Access (A4)	Kętrzyńskiego st.
5	Police	Access (A5)	Wolności st.
6	Marketplace	Access (A6)	Marketplace
7	The Cort/prosecutor	Access (A7)	Wolności st.
8	Fire dept.	Access (A8)	Matejki st.
9	Hospital	Access (A9)	Wolności st.
10	Municipal office	Access (A10)	Mickiewicza st.
11	Tax office	Access (A11)	Rataja st.
12	Node 1 - MZECIK	Access (A12)	Tysiąclecia st.
13	Node 2 – TBS	Access (A13)	Łabędzia st.
14	Node 3 – City Council	Access (A14)	Wolności st.
15	Node 4 – WDK	Backbone (BN3)	Wolności st.
16	Node 5 – Meat Proccessing	Backbone (BN2)	Kętrzyńskiego st.
17	Node 6 – TBS	Access (A15)	750-lecia Wąbrzeźna st.
18	Node 7 - MZECIK	Access (A16)	Żeglarska st.
19	Water Tower	Backbone (BN1)	Królowej Jadwigi st.
20	KPSI	IXP	Królowej Jadwigi st.
21	KPSI	IXP	Wolności st.

Distribution/aggregation nodes of Wąbrzeźno City network plays the role of backbone layer network nodes connected together by the fiber links. The backbone layer of every network should be characterized by high level of network reliability. So, over designing process of physical topology Wąbrzeźno City network structure, it has been assumed that distribution/aggregation nodes will be connected with double fiber rings. Double ring topology structures are used very often as the topology of backbone layer, as on the one hand this topology ensures high level of network reliability but on the other one, simplifies the management process of traffic transfer in the network [6]. Nowadays, in optical mesh networks, ring structures are used in wider term, creating so called p-cycles [5]. As our planned network is considered as fast recovery network the p-cycles provides the desired goal. P-cycles are always directed. When one of the links on the cycle fails, similar to a ring with multiplex-section protection, all wavelengths on the span are redirected in the reverse direction around the cycle that are used for network recovery in the event of link failure [1].

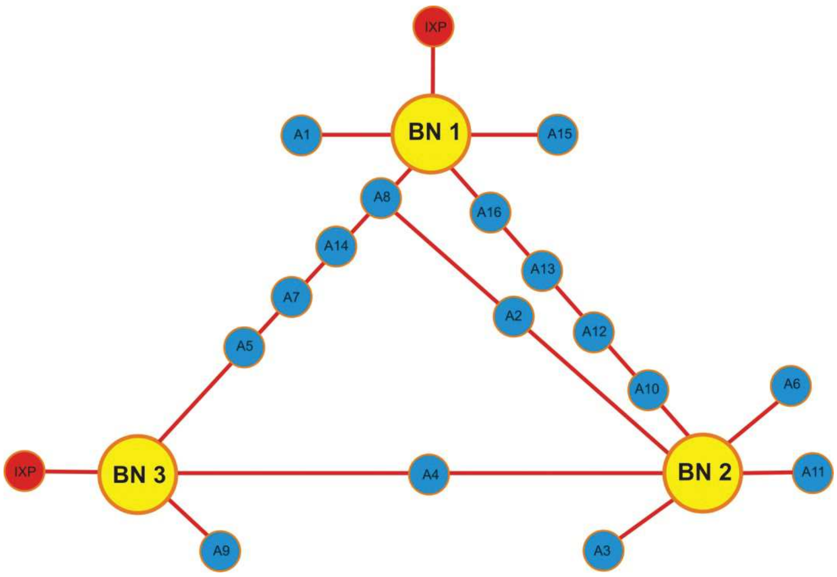

Fig. 2. Physical connection scheme following from network structure shown in figure 1.

The way of increasing reliability level of traffic transfer in the ring structure uses one of well known methods of link or path protection. The main principle of protection lies in fact that all selected pairs of nodes, that communicate with each other, are connected by two disjoint routes. In double fiber optical ring, each of these paths uses single optical fiber. One path is called working path and the second one, protecting path, They are implemented with the use of disjoint rings. Traffic transmitted from any two nodes in backbone goes through dedicated fiber with a total throughput of 10 Gb/s. As in Wąbrzeźno City network three backbone nodes are connected without any optical system like xWDM, so communication between any two nodes, in working or protecting paths, are always done via the third node (either in working or protecting path).

On the basis of fiber rings layout depicted in figure 2, real physical network structure of Wąbrzeźno City has been modified to "traffic oriented network". Modified Wąbrzeźno City physical network infrastructure includes two fibers rings, that join three backbone nodes denoted as BN_1, BN_2, BN_3, and 16 links joining access nodes to backbone ones. The figure 2 is supposed to visualize the idea of the physical connections. Nevertheless the access nodes which lays between backbone nodes do not mediate the same path with backbone nodes what will be explained in next section. The modified physical fiber cables structure of Wąbrzeźno City IP network is implemented in the form of double fibers ring connecting distribution/aggregation nodes (backbone layer), and branches (spurs), joining backbone nodes with access ones located in the city. The real structure of Wąbrzeźno City network topology, build on a physical basis of topological structure presented in figure 1, is shown in figure 3. From figure 3 outcomes that two backbone nodes BN_1 and BN_2 are connected to regional (K-PSI) network via IXP. Two connections of Wąbrzeźno City network with regional network has been assumed to increase the level of reliable transfer to the global Internet. Practically the connections to IXP points are realized via two 1 Gb/s links located in backbone nodes.

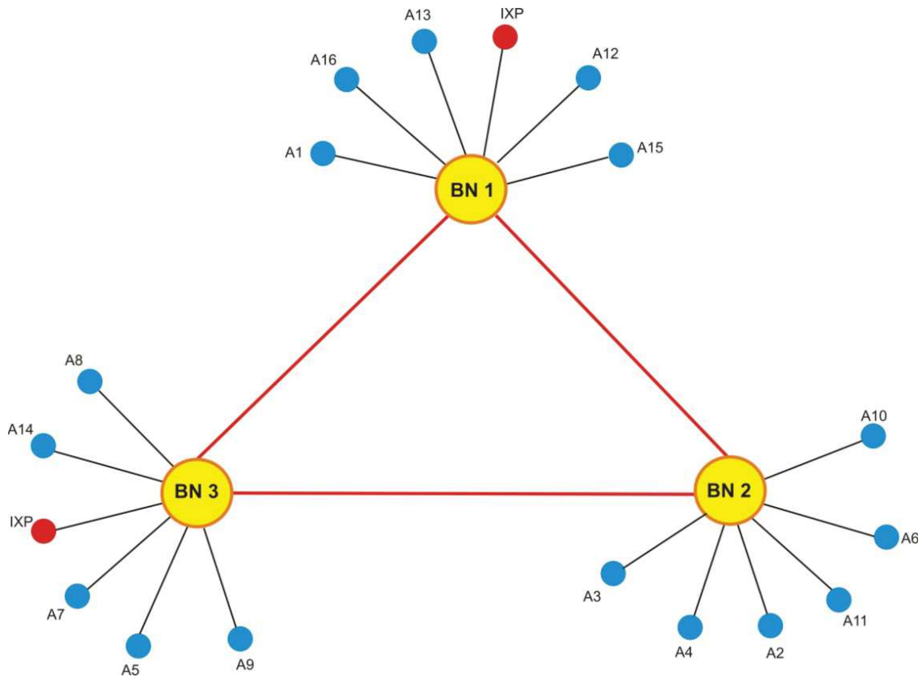

Fig. 3. Logical topological structure of Wąbrzeźno City IP network

To provide a wide range of scalability of the planned network, it has been assumed that the main nodes of the network (backbone ones), are to be connected to each other using links with transmission capacity of 10 Gb/s, while the access nodes has been joined to the backbone nodes using links with 1 Gb/s transmission capacity. Logically, the access nodes together with backbone one, forms a star topology (the optimal topology for "traffic oriented network") with backbone nodes as the main star nodes.

Functionally, both the backbone and access nodes of Wąbrzeźno City network meet mainly distribution (aggregation) functions, as their role is traffic transfer, to (from) main nodes BN_1, BN_2, BN_3, from (to) access nodes and further to (from) regional network and then to (from) global Internet. All access nodes lying both, on network ring or outside network ring are connected with dedicated fiber to only one backbone node. Admittedly, the star structure of access network does not guarantee high level of reliability, but it is the cheapest structure, that allow efficient traffic transfer. In fact, the damage of a fiber optic link will affect only the small group of users.

To be able to realize the topological structure of planned network (depicted in fig. 3) the suitable usage of optical fibers is needed. The main idea of fibers usage is shown below in figure 4. Access nodes located on the spurs of network structure are connected with dedicated fibers to the ring, and then using dedicated ring fibers, to backbone nodes. Access nodes located in the ring has been connected to backbone nodes using fibers in the ring. Connections of access nodes located in the ring are realized out as follows: in each relation (optical cable joining neighboring nodes) one pair of fibers (let us take the pair with number 1) is used for connection of backbone nodes. The other pair of fibers in analyzed relation can be used for connection of access nodes located in this relation with the nearest (and only one) backbone node. To connect each access node, the described idea requires to use separate pair of fibers. Obviously, similar situation is when connecting access nodes on spurs, as in the ring the fibers for joining spur nodes are chosen in the same way as the fibers for connection of access nodes lying in the ring.

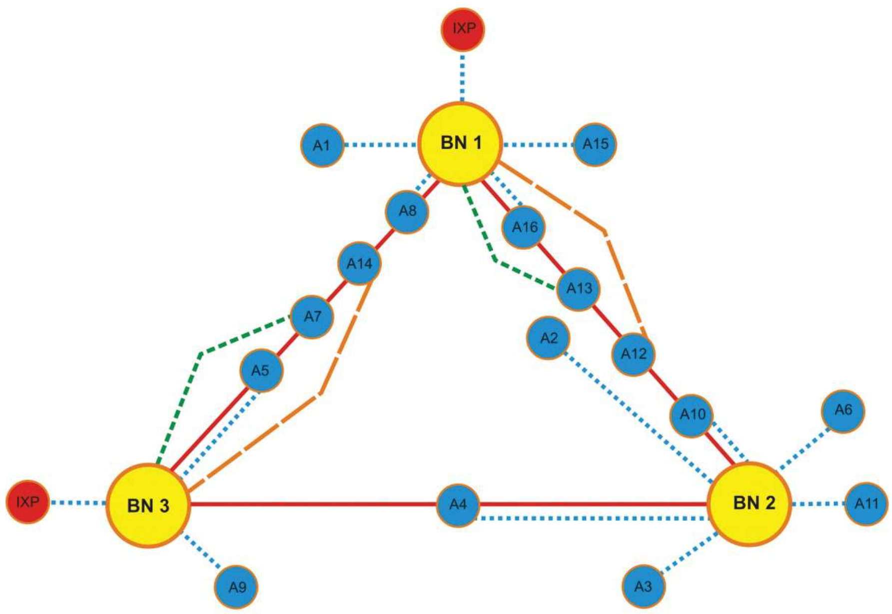

Fig. 4. Physical fibers connections for backbone and access network implementation.

To reduce the number of needed fibers, it has been assumed that the pair of fibers in the cable with the same number can be used repeatedly, however, two access nodes located in the network ring can be connected, with the same number of fibers pair, to different backbone nodes. For example, in figure 4 it has been shown that the pair of fiber marked with a dotted line (let us assume fiber pair with i-number) connects, in the same cable relation, A_{16} with BN_1 and A_{10} with BN_2. The described above method of fibers reuse, gives topology required minimal number of fiber pairs usage. For network presented in figure 3, the construction of this network require only four pairs of fibers.

The Project of the passive physical network layer (fiber optic network) involves the construction of the network using Modular Cable System (MCS) technology with the usage of one pipe equipped with three micro pipes. The assumptions about the construction of passive infrastructure are as follows:

- The fibers optical cables are done based on the MCS system.
- Pipes used are suitable for dig in MCS cable directly in the ground. The pipes are equipped with 3 micro pipes. The fiber cable can be blown into each of micro pipe.
- In the first stage of project implementation to one of three micropipe fiber cable is blown. The cable contains 96 fibers on the basis of 8 micro cables with 12 fibers in each micro cable.
- To extend the network transmission capacity in the future, at each 1 km distance cables are placed into bunker.

The total length of fiber infrastructure in Wąbrzeźno city is about 12 km long. To estimate Wąbrzeźno City network investment cost, it has been assumed (information were obtained from different telecommunication companies), that the average cost of 1 km fiber cable implementation is around 110 thousand PLN. So, the total cost of Wąbrzeźno City network passive infrastructure (fiber cabling) was estimated on 1,3 millions PLN.

4. ACTIVE INFRASTRUCTURE OF WĄBRZEŹNO CITY NETWORK

As, it has been discussed in the previous parts of this paper, in order to improve reliability of Wąbrzeźno City backbone network the dual ring topology has been proposed for it. Dual ring network topology connecting backbone nodes ensure connectivity of backbone even in the event of network failure. However, access nodes joined to the backbone nodes create the configuration of star topology that is relatively inexpensive to implement and easy to locate of any failure in the network. From planned network physical layer description follow that each access node is connected to one backbone node with one pair of fibers only. It is clear that such connections do not give any redundancy, as it is in the case of backbone nodes, so the connection between each access node and backbone node results in a total cut of services offered by the network. However, access layer star topology significantly reduces the CAPEX and OPEX costs and possess big impact on the later stage of proposed network development and exploitation.

Before the necessary choice of the equipment is possible it is essential to evaluate the total volume of traffic generated in Wąbrzeźno City network. The traffic in this network has been calculated in accordance with the procedure outlined in the paper [8]. For traffic evaluation the following assumptions has been taken:

1. Around 20% of all households in Wąbrzeźno will be connected (via ISP networks) to Wąbrzeźno City network. Average capacity of user access line will be 6 Mb/s;

2. Around 15% of total number of SME companies (Small and Medium Enterprises) will be connected to planned network. Average capacity of business user access line will be 20 Mb/s;
3. All educational institutions, government, and local government agencies, health care, police department, fire department, municipal and county offices will be connected to designed network. Average capacity of access line for institutional users will be 10 Mb/s;
4. Overbooking factor is assumed as:
   - 20 for residential users,
   - 10 for business user;
   - 6 for institutional ones.

Taking into account the assumptions presented above, total volume of traffic generated in Wąbrzeźno City has been estimated equal to 500 Mb/s.

As an active equipment for the network the following options has been considered:
1. optical CWDM system and routers or switches;
2. routers IP with path protection;
3. Metro Ethernet switches with path protection.

Considering in detail three possible active equipment options, the one that has been suggested is the option number 3, i.e. Metro Ethernet switches with path protection. This option is both, cost (allows to build the network with minimal cost) and bandwidth effective (ensures high throughput). The details requirements for Metro Ethernet switches installed in Wąbrzeźno City network are given below:

- Two neighboring backbone nodes connected (on double fiber rings) to the third one are using 2 optical links with capacity of 10 Gb/s. Such high capacity of backbone connections will allow to operate Wąbrzeźno City network of over next few years, ensuring network scalability of at least 10 years and guaranteeing the appropriate level of services offered in the network. Switches ports of 10 Gb/s capacity should be equipped with optical interfaces ensuring proper transmission on 10 km range. Every Metro Ethernet switch installed in backbone layer node additionally should support MPLS protocol, as the protection functions in the backbone will be provided by MPLS protocol. MPLS protocol ensures traffic switching into protecting path in the case of working path failure.
- Each backbone node is equipped with 24 optical ports with 1 Gb/s capacity, through which these nodes will be connected to lower level access nodes, located throughout the city. Similarly to the specification of backbone ports, also 1 Gb/s access ports should provide efficient transmission of 10 km distance.
- In access nodes the switches are equipped with one 1 Gb/s optical port (for connection with backbone node) and at least 6 wire ports (for user connection) with capacity 1 Gb/s.
- It has been assumed that active equipments of backbone nodes are installed mostly in the indoor cabinets. The cabinets are equipped with power supply unit, air condition device and UPS module. The outdoor cabinets are only located at the police station, hospital, fire department and City Hall, as there was no possible to install indoor ones. Outdoor cabinets are also equipped with air condition devices, power supply unit as well as UPS.

In designed Wąbrzeźno City network the backbone nodes have been located in three main locations: Water Tower, Meat Processor and WDK. It should be noted however that described network would operate in future as Carrier of Carriers network type, where the users (both residential and business) will be joined to the network via local ISP networks. So, in the planned here network do not exist access lines connecting end users, as in fact this city network is "last mile before" network.

It has been suggested that the Wąbrzeźno City network should be connected to the global Internet via Kuyavia-Pomerania Regional Broadband (K-PSI) network. The Internet Exchange Point with K-PSI network will be installed in two backbone nodes located in a Water Tower and WDK. It has been assumed also that connection between Wąbrzeźno City network and K-PSI regional network would be implemented for every node through two links with of 1 Gb/s each (all together 4 Gb/s).

The total cost of active infrastructure installed in Wąbrzeźno City network has been estimated on 700 thousand PLN.

5. CONCLUSIONS

The paper is devoted to the designing project (plan) of Wąbrzeźno City network. In the paper, the topological structure of fiber optic network as well as the final solution for active layer of the network has been presented. For construction of passive infrastructure the technology of Modular Cable System – MCS has been suggested. Within this technology the fairly wide range scalability and cost effective network has been provided.

For the construction of the city network active layer the Metro Ethernet technology is used. Metro Ethernet technology provides a low cost of construction (CAPEX), ease of implementation of the network and low operating cost (OPEX). The parameters of installed network switches (switches) Metro Ethernet guarantee the scalability of the network for at least 10 years. The project assume also, that the city network in Wąbrzeźno cooperate with the regional K-PSI network (Wąbrzeźno City network and K-PSI network exchange traffic via common IXP point).

Total investment cost of Wąbrzeźno City IP network is estimated on 2 millions PLN.

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SZEROKOPASMOWA SIEĆ IP DLA MIASTA WĄBRZEŹNO

Streszczenie

W pracy przedstawiony został projekt szerokopasmowej sieci IP dla miasta Wąbrzeźna. Rozszerzona wersja projektu stanowi część techniczną Studium Wykonalności zadania, które będzie wdrażane w mieście Wąbrzeźno. Zadanie to będzie współfinansowane z funduszy Regionalnego Programu Operacyjnego. Prezentowany w pracy projekt sieci zawiera zarówno opis części pasywnej (topologia kabli optycznych), jak i części aktywnej. Dla budowy części pasywnej sieci sugeruje się wykorzystanie systemu mikrokabli. Z kolei, dla budowy części aktywnej sieci sugeruje się wykorzystanie przełączników (switchy) Metro Ethernet. Zaprezentowane w pracy rozwiązanie zapewnia niski koszt inwestycyjny (CAPEX) budowy sieci, łatwość implementacji oraz niskie koszty operacyjne (OPEX). Ponadto także parametry wydajnościowe zastosowanych w sieci przełączników Metro Ethernet zapewniają skalowalność sieci przez okres co najmniej 10 lat.

Słowa kluczowe: szerokopasmowy, sieci IP, aktywna infrastruktura, pasywna infrastruktura, sieć szkieletowa, sieci dostępowe.