More light in Polish optical fibres

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ABSTRACT

Optical communications infrastructure is undergoing an intense development in his country now. A number of international investors and domestic operators are building from the beginning, modernizing or developing proprietary network or leasing wide area systems on a large scale. The aggregate level of these processes is of the order of bil. $. Despite of this the network is not homogeneous, has not satisfactory bandwidth, lacks the QoS, has inadequate international connections, and (according to prevailing opinions) the prices are too high for corporate as well as private users. The intense development of the optical infrastructure is governed by two dominant tendencies: burying new large, fat, optical pipes – cables containing even as much fibers as 500 (for C, L and XL optical bands) and investments in DWDM for main traffic directions (previously working in 1300 nm band).

Keywords: Optical fibre technology, optical fibers, optical communications, optoelectronics, Internet

1. INTRODUCTION

The economic crisis of the last decade has touched also certain sectors of the communication field, in particular cable carriers, and to a lesser degree wireless and mobile carriers. This enforces strong consolidation activities in the global scale. The telecom market is segmented and re-grouped. Big operators aim frequently at new investments in such conditions. These processes can be observed on domestic telecom market in this country.

The last years are a period of very intense investments in optical fibre communications infrastructure in this country, especially in backbone networks. Several operators carry out the investments: Telia, Energis, TPSA, Netia, Telbank, Tel-Energo, Railway-Telecom and others. The business networks are built using existing, specialized infrastructure. Railway-Telecom lays optical fibre cables along the national railway tracks. Electrical Power Telecom lays aerial fiberoptic cables along power lines of 110kV, 220kV and 400kV. Optical cables are laid along new roads, motorways and oil pipes.

Despite very broad scale investments in business communications the statistics is not favourable for this market. The average bit rate counted for an individual inhabitant and unitary area of the country is far from the achievements in the European leaders. A lot of effort has still to be done. The opinion in the business, research-technical and first of all user circles, in this country is that the telecom market is developing at too slow rate. Popular and cheap Internet access, with terabit optical network as its technical background, is far from practical realization. Strong pressure on cheap solutions comes from Internet users, businesses and media integrators. Slowly, however, the period of telecom monopoly passes away.

It is to be emphasized once more time that despite intense investments in optical network infrastructure by several cable operators in this country, the available transmission resources are not sufficient and this situation will not improve for a few next years. The structure and division of the users telecom market is still very unfavourable. Only about 10%, out of nearly 11 million, is registered outside TPSA. This situation should change in the nearest future. The administration prepares several solutions, which should accelerate the development of competition on the telecom market in this country. It is necessary to introduce mutual financial calculations of the costs to use partners’ infrastructure. Exchange
of cable and network resources will be obligatory among the carriers on a competitive market basis. Such agreements are now realized with great difficulty, mainly due to the privileged position of major and dominant operator TPSA. A proof of this is recent nonsymmetrical agreement between TPSA and NOM (Nondependent Intersphere Operator). The lack of such agreements blocks the market form the legal side. One of the ways of very fast bandwidth increase in the domestic and international networks in this country is the introduction of very dense DWDM.

2. DIRECTIONS OF DEVELOPMENT OF OPTICAL NETWORKS IN POLAND

The main driving force of fast development of optical networks, also in this country, is explosive growth of the Internet [1]. The global network offers the whole palette of services: email, WWW, file transfer FTP, catalogue services, information storage, Internet telephony and videotelephony (VoIP), video on demand, Internet TV, teleconferencing, distant learning, e-trade, e-banking, stronger integration with mobile wireless telephony, distant work, localization of persons, Intranet, Extranet and SAN networks, and big groups of newly designed future services like virtual reality, tele-immersion and telemedicine.

There are observed in this country two basic directions of development of optical communications infrastructure. One is installation of wavelength multiplexing systems superimposed on existing optical lines [2]. These lines were built several years ago. This solution is realized on the most burdened communications directions. The second solution is much more expensive. It is connected with building of totally new optical fibre lines in the most used directions and in quite new directions [3]. One of the most important problems is integration of a large variety of domestic systems with the European communications infrastructure. The number of such connections is now too small. Several carriers are now developing international connections.

A number of routine measurements are necessary before it is possible to introduce a WDM system on existing optical communication channel [4]. The existing old channels have previous generation of G.652 fibers (ITU-T). These measurements embrace: particular, chosen parameters of individual optical fibers in the cable, preparatory measurements, pre-exploitation measurements, acceptance measurements, and periodical exploitation measurements, post-deployment. Deployment of a WDM system on existing optical transmission lines (which were not newly built) requires very precise bi-directional measurements of all involved fibre lengths (which create the transmission path). The parameters of applied WDM devices (to particular fibre and optical cable lengths) are chosen individually to the results of these measurements. The unitary attenuation is measured in both directions $\alpha$[dB/km], chromatic dispersion $d_c[\text{ps/nm} \times \text{km}]$, optical attenuation of fibre splices and mechanical joints and overall optical link homogeneity and integrity. The typical data for G.652 optical fibres optimised for 1310 nm band (and which are predominant in the installed optical systems) are: $\alpha\leq0.4$ dB/km dla $\lambda=1310$ nm; $\alpha\leq0.25$ dB/km dla $\lambda=1550$ nm; $d_c\leq3.5$ ps/nm$\times$km dla $\lambda=1285\div1310$ nm; $d_c\leq520$ ps/nm$\times$km dla $\lambda=1525\div1575$ nm. The level of dispersion of G.652 fibre designed for 1300 nm and working now in the C and L bands is a confinement up to the level of STM-64 at properly reduced repeater distance.

Optical fibre networks developed in the future not only in this country by all carriers and operators must integrate the variety of traffic generated in access networks of big and ever increasing variety. It is necessary to remove some protocol layers especially these, which are doubling and partially covering each other. Such a future network is called a transparent one. Transparent network is homogeneous in signal sense. There is only a single optical WDM layer. It is also protocol homogeneous since there is only one TCP/IP protocol. It is however next generation TCP/IP, now ver.6 extended with MPLS protocol (Multiprotocol Label Switching). Such next generation IP (IPNG) is imposed over the colours of WDM transmitted in a fibre. The number of networks levels is reduced to the minimum. It is even difficult to distinguish between LAN and MAN (also WAN) levels in some of the modern and future networks. Network interfaces for different users and between different networks are getting more unified and similar. Management of the wavelengths is done with the aid of MPLS (Multiprotocol Lambda Switching) protocol, which is analogous, in some sense, to MPLS, but here concerns switching the lambdas and labelling/routing the packets of different colour in optical nodes of the network. The method allows for sending of packets along a multicolour transmission path, optimally chosen to the dynamically available network resources and prevailing traffic conditions.
International normalization agreements are necessary to build such a transparent network. The standards concern the development of IPNG protocol and its supplementing with QoS (Quality of Service) management. Normalized control and protection sub-layers of the network are required. They are situated either inside the TCP/IP or directly inside optical WDM. These functions have to provide for fast network restoration, in agreement with international standards, for example, concerning synchronous optical networks like Sonet/SDH. There are several parallel, more or less dependent, lines of work in this area. The work on IPNG embraces DiffServ protocol (providing for Differentiated Services), inter-networking protocol OBGP (Optical Border Gateway Protocol), MPL/LS protocols, and a number of others. The work on WDM/DWDM embraces standardization of Digital Wrapper (DW) technology. DW is a kind of a TDM frame consisting of load area and complex heading. The header carries information allowing for transmission quality control, various error corrections – for example, FEC, as well as for network protection and transmission restoring.

The structure of network intelligence is concentrated in the, so-called, intelligent, optical routers. The routers have functionalities of optical signal switching OXC (Optical Cross-Connect) and IP/MPLS routing. The optical routers have the ability to recognize network’s topology. They can choose optical channel, may create optical path for packets, actively route wavelengths, and optimise available optical resources of the network. It is anticipated that the introduction of optical routers on the borders of the network will reduce considerably the number and variety of equipment used today in the backbones. The functional structure of the network is flattened in this way. Flat optical network is expected to have much greater efficiency (greater bit rate, bigger efficiency of capacity usage, bigger reliability, lower installation and exploitation costs, etc.).

The major features of totally optical networks are: practically no confined transmission bandwidth, structural simplicity (single layer structure, IP over DWDM), small transmission lags, practically zero bit error rate, continuous optical monitoring capability (embracing supervision and evaluation of transmission quality). Continuous monitoring bases on Digital Wrapper technology, which is a single and homogeneous mechanism for all optical network. Other features of totally optical networks are: big resistance to damage through network protection simultaneously on optical and protocol layers, very fast network reconfiguration in case of damage, very fast creation of new optical paths through switching of lambdas, optimal usage of network resources, ability to co-operate with a large variety of access networks (including optical and non-optical ones, different hardware and signal formats), flexibility to expand.

### 3. MEASUREMENTS AND MONITORING OF BROADBAND OPTICAL NETWORKS

The optical networks get more and more enhanced and brand new functionalities these days. These functionalities include: broadening of the transmission bandwidth; introduction of wavelength multiplexing systems; considerable increasing of the level of optical power propagating in a single, transmissive, singlemode, optical fibre; introduction of transparent optical networks (residing on optical routers); complication of network structure through much more branches going to a single optical node (multi-eye structure instead of loop), and a lot more. Evolutionary change in the optical network structure and functionalities requires introduction of automatic monitoring sub-layer. A number of monitoring functionalities bases on the on-line, real-time, measurements of many network’s technical parameters and its performance as a whole. The parameters to be measured continuously are: optical power level in individual optical channels, optical power level in individual fibres, stability of optical power in channels and fibres, attenuation and dispersion in optical channels, the level for optical nonlinearities in transmission channels and fibres, main wavelengths of the systems, thermal and temporal stability of the main wavelengths, optical cross-talk between the channels, channel separations, optical noise, optical signal to noise ratio OSNR, optical channel reflectances (backscattering), quality of the optical system clock (PRC primary clock coordinated with universal time scale), quality of fibre splices and joints, local (point like) mechanical damages to optical cable giving changes in the OTDR trace, improper radius of optical cable laying (too big bending), other mounting errors. The measurement apparatus used for optical network monitoring are: optical spectrum analysers OSA, variable optical attenuators VOA, transmission system analysers (IP, SDH, ATM,…), tuneable optical sources, wavelength meters, optical power meters, optical reflectometers, refractometers, etc. The network requires (apart from strictly optical measurements) also monitoring of system parameters like: launching (booting) of the system, alarm generation procedures, reports, etc.
The number of monitored and continuously measured parameters of optical network gets larger and larger with network development. These measurement data should be further processed, gathered, stored and made available in a useful form for the network operator. The functionalities of the monitoring system should include some automatic functions like: reactions to crossing of nominal or threshold values of some parameters, generation of alarms, logs, and visualization for the operator. The management systems of simpler networks evolve from individual proprietary solutions to an open DHTML platform. This platform bases on data about network elements, measurement database and measurements done in real time with interactive operator’s access. Such solutions are obligatory in IP networks. The standardization of operator’s network interface (management, monitoring, measurements centre) will lead, in the future, to lowering the costs of network operation. Now the prevailing type of network operator interfaces are closed proprietary solutions, which are specific for chosen kind of the network. The solutions are also tailored to the type of used network hardware, even for particular manufacturer. Future interfaces will totally abstract from network structure, topology, hardware and software. More and more frequently the network management centre bases on the ITU recommendations called TMN – Telecommunications Management Network. This architecture possesses three levels: EL – Network Elements Level, EML – Management of Network Elements Level, NML – Network Management Level. For example, the group of functions to monitor the state of the network and steer the components, belonging to the EML, includes also measurement tasks.

The measurements of the optical network can be gathered in three categories: laboratory (introductory tests of newly deployed WDM system), pre-deploying (just before the beginning of system exploitation of newly built one), exploitation (routine, periodical during system’s life). One of the tendencies in the networks of new generation is to replace periodical exploitation measurements with continuous ones. The results of measurements and monitoring of the traffic, errors, network configuration and individual parameters of optical links are placed inside the digital wrapper. These data are then read out in chosen nodes of monitoring by intelligent supervision optical routers. The reaction to changing data may be simultaneous. The router, which knows the actual state of the network, may instantaneously change configuration of the network. Reconfiguration may include change of the colour (optical channel), fibre and optical cable. Reconfiguration may also include the IP layer.

4. POLISH TELECOMMUNICATIONS S.A. (TPSA)

The biggest national carrier and operator TPSA signed a number of agreements during the period of 2000-2001 with the major manufacturers of telecommunication hardware and international carriers. These agreements concern rebuilding and expanding of their proprietary optical cable infrastructure in this country [5]. Last year was devoted to installation and deployment work on the system containing hardware for STM-16 from Alcatel and WaveStar OLS 400G from Lucent. Toward the end of last year, a DWDM system was launched allowing for sending of from 40 to 80 optical lambda channels on a single fibre in 1550 band with the rate of 2,5Gbit/s and 10Gbit/s for a single lambda (TDM). The aggregated flow was designed from 400Gbit/s to 800Gbit/s per a fibre pair. The system has a loop structure spanning the whole country and enhances the optical infrastructure of TPSA considerably.

Not all DWDM system capacity will be used from the very beginning. The network was designed with some redundancy, taking into consideration not only time development of the system but also reconfiguration possibility, building of various inter-sphere SDH loops, which would considerably increase the resistance of the system to optical link and node failures. The DWDM hardware is equipped in protection switching mechanisms directly in optical layer. There is also implemented a nondependent network restoration in SDH layer. Both protection mechanisms have to be precisely correlated with each other to avoid the oscillation phenomenon of the network topology. This oscillation is dangerous to the whole network stability. The network scalability, through larger number of optical channels, is protected by the possibility to add universal transponders cooperating with SDH, ATM and IP systems. Fig. 1 presents a block diagram of physical structure of the debated system.

International connections of this system were expanded during last year of 622Mbit/s as a result of agreement between TPSA and Telia Co. This capacity is composed of a few STM-1 links, 155Mbit/s each, going out of the country. A further expansion of the existing system is planned soon through technology change to 2,5Gbit/s link capacity. Next planned system capacities are 10Gbit/s and 40Gbit/s.
TPSA started the installation of optical fibre cables in their networks and on a large scale from the installation, in the very beginning of the previous decade, the NSL (North-South) and EWL (East-West) trunk optical links. PDH systems rested then on these links. The construction of basic optical infrastructure was started in the middle of previous decade. SDH network used NEC hardware. The total length of links was 13,000 km and the capacity was 622Mbit/s in regional network level and 2.5Gbit/s in transit level. The network had 12 transit nodes and approximately 50 end nodes. The network possesses also transit repeater (regeneration) stations.

5. TEL-ENERGO S.A.

The second biggest optical network in this country was built by Tel-Energo (Electrical Power Telecom) [6]. This carrier and operator is a major provider and telecom service integrator for electrical power sector. The sector includes: Regional Electrical Power Departments (RZE), Polish Electrical Power Networks (PSE), Electrical Power and Heating Stations. TESA is also a provider of infra-structural services for big corporations and other carriers and telecom operators.

Aerial, optical fibre network of TESA has currently 11,000 km of cables integrated in either electrical ground wires or totally dielectric ones. The first technology is called OPGW – Optical Ground Wire and the optical cable is integrated with the electrical power transmission system, while the latter ADSS – All-Dielectric Self Supporting and the optical cable is spanned autonomously. The difference between the technologies is that in the first case the cable is metallic, while in the second case all-dielectric. The mentioned 11,000 km of optical network connects above 100 cities and towns in this country. TESA is constantly developing of its optical network continuously extending cables along the aerial 110kV electrical power lines. These lines belong to the local RZE. Some RZE possess their own optical fibre lines. In such a case TESA leases these lines. TESA also manages the optical fibre lines belonging to the PSE, which are placed along the 220kV and 400kV systems. TESA network has also a few leased lines from outside the electrical power business sector.

TESA network possesses classical three-layered structure: transport, backbone and regional. These layers are realized accordingly by DWDM hardware, SDH STM16 and STM4. TESA network has available bit rates in the following order: 155Mbit/s, 622Mbit/s, 2.5Gbit/s and 10Gbit/s. The access networks have ISDN systems (dial 0-27) and single and multiplied links of 2Mbit/s, up to 34Mbit/s. The transport network is built of 32 lambda WDM system, with STM-64 for each lambda channel. Thus, the aggregated capacity is 320Gbit/s. The network is evolutionary aiming at grid architecture. The backbone network, done in SDH technology has classical loop architecture with a single network management centre. The hardware is chosen in such a way as to enable easy integration of the networks from various levels, and in particular from backbone and regional ones. Development of TESA networks is planned in direct IP over DWDM technology in the future.

TESA regional networks usually embrace the areas of activities of particular RZE. Development strategy of TESA assumes increasing the bandwidth through application of STM-64 equipment, building of new optical lines, and broad applications of WDM. The first solutions of OPGW technology (several years ago) allowed for placement of 12 fibres of ITU-T G.652 type in a ground wire. The TESA network possesses a lot (majority) of such lines. Now the ground wire has up to 96 optical fibres (and the plans are for even more). It is necessary to replace the ground wire in the most burdened directions by telecom traffic. The other solution is to introduce there the WDM solutions. TESA network was enriched by a few thousands km of DWDM systems in the period of 2001-2002. TESA network is now intensely developed in international connections layer. A separate optical SDH loop is built serving only the international traffic and connections. Figure 2 presents schematically the TESA network.

TESA carrier and operator deploys, in cooperation with other telecom hardware manufacturers (like Pattern Counications, Main.net and others) PLC system of Internet access through 220V home electrical network. A number of agreements were signed with local RZE. The implementation plan assumes installation of comparatively cheap Internet access in 5000 end users. The market interest in PLC is quite high and new firms, competing with TESA, are entering the niche. These firms sign their own agreements with local RZE. One of such firms is ESCOM Poland, which installs PLC in Cracow. PLC system allows for additional, distant electrical power consumption measurements.
The TESA network management centre is located in National Electrical Power Disposal Centre in Warsaw (KDM). The basic functions of the centre are: network configuration, breakdown management, monitoring of network efficiency and safety provisioning. Network configuration consists of resources identification, finding of dependencies between pieces of resources and management of resources and dependencies. TESA network managing operator has mobile operating technical teams, which supervise network exploitation and maintenance. The aim of these technical teams is to provide for high network operability.

6. RAILWAY COMMUNICATIONS S.A.

The Railway Telecom Company was formed from National Railway Co (PKP). The main aim of RCSA is to serve the telecom needs of railway telecom and be the operator of the railway telecom infrastructure. National Railway decided to enter the telecom market because of big increase in data transmission needs inside the railway sector and in the country [7]. PKP strategy and its daughter telecom company RCSA is to build their own optical cable infrastructure. The network development was comparatively fast and some parts of the infrastructure were dark. Part of the infrastructure (now about 30%) is leased on the basis of dark fibres by other carriers, for example by Polish Optical Internet Pionier. The carriers lease particular lengths of non-powered by PKP optical fibres, including them between their own end stations. The first realized DWDM line by PKP was situated between Wroclaw and Poznań. This line was included in Polish Optical Internet Pionier network in 2000. Confined financial possibilities of PKP cause, that the investments are divided to smaller stages. The money obtained from leasing of optical cables are re-invested in further network development, proportionally to the increasing needs of the customers.

PKP develops systematically its optical cable infrastructure laying cables along the railway tracks. Now it possesses one of the most extended optical network in the country. The total length of optical cables has recently crossed a milestone of 5000 km. PKP cooperates with international partners. Together with these partners, it recently has launched a WDM system of 2,5Gbit/s rate for individual TDM channel. The system is being developed in the direction to increase the capacity. Introduction of 32x10Gbit/s standard is expected soon. The backbone line of the system is Warsaw-Berlin-Frankfurt/Main. The network consists of optical trunk lines from which the carries may build large and local loops. The carrier assumes also the possibility to build a few metro loops in the biggest cities and agglomerations of the country. Most of the cables have fibres which fulfil the ITU-T G.652 recommendation. Similarly to other carriers, the telecom operators can lease from the PKP Telecom links of the following bit rates: 2Mbit/s Nx2Mbit/s, 34Mbit/s, 155Mbit/s, 622Mbit/s, 2,5Gbit/s and 10Gbit/s. Direct connection to access points is possible in nearly twenty cities of the country. PKP Telecom not only leases optical lines but also is an operator of railway 2Mbit/s network called Kolpak. Fig.3 presents the development plans for PKP Telecom optical network.

7. TELBANK S.A.

BPT Telbank was established several years ago to serve the telecom needs of the banking and financial sectors. From the beginning of its activities Telbank used optical cable infrastructure of TPSA and TESA. In parallel it started to build its own optical and satellite telecom infrastructure. The optical backbone was assumed from the beginning to be gigabit. Now it is working with STM-16 hardware, i.e. 2,5Gbit/s. This network is intensely developed all the time, and the investment started in 2000 [8]. Telbank has built recently two optical lines along the path linking the following cities: Warsaw, Płock, Włocławek, Toruń, Bydgoszcz and Warsaw with Cracow. The big loop is expected to be completed in 2002. It will be closed through Katowice, Wroclaw, Poznań and again to Bydgoszcz. Te total length of optical cables in Telbank network will reach 5000 km soon. Back-up for the Telbank optical network is a satellite one. Telbank uses now the biggest telecom satellite network in the country.

Fig. 4 presents the map of cities and towns serviced now by the Telbank network. These localizations are being connected systematically by own Telbank network. Recently Telbank has offered telecom services for businesses outside the banking and financial sector. It is anticipated that the Telbank network will be used by Pionier – Polish Optical Internet, and some programs like Intelligent Building and City Quarters, UE sponsored program eEurope – An Information Society for All. Telbank network is going to specialize in sending in an integrated form radio and TV programs, information services, multimedia services. BPT Telbank is going to specialize in media leasing to private
virtual networks PVT with quality of service (and in particular bandwidth assurance). Fig. 4 presents Telbank optical network.

8. POLISH SCIENTIFIC OPTICAL INTERNET ‘PIONIER’

The initiative to build a new generation of Internet basing on optical technology was undertaken by research, academia, communications and industrial environments, among other places in Poznań and Wrocław. The Pionier network has used, during the first period, the telecom infrastructure of National Railways PKP. These optical lines were situated along the railway tracks. Using of existing optical cable infrastructure lowered considerably the overall costs of the system and shortened the time of investment, tests and deployment. The new optical cable infrastructure is to be built along the motorways. Pionier will use also the telecom infrastructure built along power lines, raw oil pipes, etc. The parameters of Pionier networks are set by the UE for the European Optical Internet system GEANT - Gigabit European Academic Network.

Deployment in this country a modern Next Generation, Multigigabit, Optical Internet Network requires building of new dense, broadband transmission infrastructure. The only fast solution are DWDM systems, initially installed on leased fibres and next built as own systems from the beginning along the new motorways. In the beginning the network integrates ATM and IP transmission. The Optical Internet Network should serve several layers of today’s applications. These are: national meta-computer, data archives, distant learning, tele-medicine, popular access to the Internet, national PC cluster, business and sectorial networks, etc. Building of backbone network must be accompanied by development of regional access networks working with gigabit Ethernet (GbE). The program of development of Optical Internet in this country must base on international cooperation from the very beginning. International cooperation is necessary to undertake, develop and realize such big project like GEANT, but also Internet2, Canet and Abilene.

Fig. 5 presents planned developments for Pionier network of Polish Optical Internet.

9. SCIENTIFIC AND ACADEMIC COMPUTER NETWORK ‘NASK’

The Internet Research and Academic Computer Network (NASK) was established in 1991. It now possesses status of a scientific institute. NASK has built a nationwide WAN type computer network. It is connected with the global network via 155Mbit/s line to Sweden. This WAN possesses now 43 nodes. The transmission rate inside the network is now 34Mbit/s but is going to be upgraded to 155Mbit/s. The main nodes of IP network are connected through backbone network in Frame Relay and ATM technologies. NASK hold a monopoly as an ISP provider till 1996. NASK has also built Warsaw Metropolitan Network ATM WARMAN. It now offers: corporation networks of international reach, international IP transit with QoS (bandwidth guarantee). The latter service is directed to other ISP operators. NASK cooperates with international carriers. It develops own network, now in optical technology.

WARMAN was built to be used by private users and businesses in Warsaw area. The MAN provides straightforward and fast access to the Internet, via constant link, from one of 33 access points in the city. It is now the biggest MAN ATM 155Mbit/s in this country. The network provides: guaranteed throughput, simultaneous transmission of computer data and isochronal signals, transmission safety, possibility to set transmission path via different routes chosen by the system, creation of virtual closed networks with totally, mutually separated traffic (PVCN) – so called safe corporation networks.

NASK carries trainings concerning deployment of teleinformatic solutions. The following tutorials are offered: introduction to computer, telecom and teleinformatic networks, router and ATM switch configurations, safety of computer networks. NASK organizes cyclic topical conferences: SECURE – safety of computer networks, WARMAN – development of Warsaw MAN.
NASK holds polish CERT WWW page and infrastructure. The security portal is responsible for such problems like: safety of operational systems on local Internet market, WWW safety, reaction to safety incidents, and methods of risk management. Portal answers all questions concerning the network security problems. Portal offers a collection of safety tools for all popular operational systems, also for FreeBSD. Portal offers the newest patches to all OS. Portal carries current information service concerning news in the Internet safety area. It publishes periodical reports.

Fig. 6. presents the maps of NASK WAN network.

10. TELIA A.B.

Telia is a Scandinavian operator, which is building its proprietary Viking Network (VN) in Europe. The VN has strong connections to the USA. Telia has recently created a regional office in Warsaw (end of last year). The task for this office is to extend VN to Middle and Eastern Europe. Now the main aim is to build a part of the backbone stretching along the Baltic Sea shore. The transmission rate for this backbone is either 2,5Gbit/s or 10Gbit/s. The Baltic Sea VN backbone is expected to be completed toward the end of 2003. Two links are predicted between Warsaw and the VN. One is leading to Hamburg and has 155Mbit/s rate. This link is now operational. The second goes to Stockholm and will be 2,5Gbit/s.

11. NETIA S.A.

Netia backbone network consists of 4000 km of optical cables. It connects nearly 20 major cities in the country. The cables were installed comparatively recently. They contain new standard optical fibres (long wavelength window) in large quantities per cable (348=8x48). This cable structure provides required capacity redundancy. There is no immediate need, according to Telia, to introduce the DWDM system. The basic installed hardware is now STM-16, 2,5Gbit/s. The WDM transmission multiplication is predicted, however, in the future. This large number of fibres available for the main transmission directions will serve not only Netia but also different carriers. Netia offer is directed mainly for business clients or for private users over the designated concession areas.

Since the middle of last year Netia offers transmission services over Frame Relay network working with rates from 64kbit/s to 2Mbit/s with guaranteed bandwidth of 1Mbit/s. Netia, analogously to TPSA (0202122) offers nationwide modem access number (0209267). Because of lack of agreement between both operators these numbers are not interchangeable.

12. ENERGIS

Next big international carrier Energis has recently started its activities in this country. The agreement signed with PKP gives Energis right to lease approximately 6000 km of optical fibres. Part of this optical infrastructure is now working in SDH/DWDM loop. Planned investments of Energis in telecom infrastructure in this country say about 300 mln. $. The investments till now reached 200 mln. $.

13. CONCLUSIONS

There is no alternative for cable telecom networks to go other way than terabit optical. These networks will be integrated in more and more dense local, regional and wide grids and then in homogeneous international global grids. Explosive growth of the Internet and mobile telecom services, data transmission and multimedia gives the hope for further planning of social development on the basis of future telecom foundations. EEurope – Information Society for All, development program by the EU is realized also in this country. The ePolska program assumes evolutionary usage
of new tools in nearly all sectors of social life like: teaching, learning, medicine, law and justice, work, research and science, culture, information, pleasure, etc.

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