Magyar Telekom Group's Research and Development Activity 2006

Magyar Telekom

Contents

Introduction

Due to the economical, social and natural challenges presenting themselves in our days, all over Europe and in Hungary, too, a new stress has been laid on innovation and research and development. The slowing down of the pace of the economic growth and competitiveness, the unfavourable demographic trends, the reducing stocks of fossil energy sources, the uncertainties in supplies and the climatic changes necessitate the further development of technologies, the increasing of knowledge and pursuing of high level research work.

The role players of the economy all over the world encounter new economic, social and cultural challenges and adaptation to the ever changing market conditions has become an issue of great importance for the companies to meet the society's emerging new requirements. Magyar Telekom, too, is one of the players shaping this market environment. Under the given challenging conditions the Company wants to strengthen its leading position achieved in the telecommunication sector through the optimized exploitation of the financial, economical and technical/ technological results of R&D.

The today's info-communication technology is already characterised by convergence. On the spur of digital techniques the so far separate industries, like, for instance, telecommunications, informatics, media and entertainment electronics, have started to make for a common evolution direction, and therefore it is more difficult to draw a dividing line among them. These changes go along with the speeding up of globalization. It shows the changes as well, that today the users may get involved into the development process already from the early phase of it, shortening with that the duration of the development.

Looking back to the last decades, all important network and product development projects of Magyar Telekom have always been preceded by proactive R&D activity that greatly contributed to the timely, economical and high quality implementations and introduction of services. Our current R&D activities focus on the obtaining of core input information forming the pillars of Magyar Telekom Group's middle- and long term technical and strategic platform developments.

The Magyar Telekom Group's Integrated Strategy (2007-2009) mentions Next Generation Networks (NGN) and the moving towards the (full) IP-based products among the key technological drivers of the (2005-2010) industrial trends. Special emphasis is put on wireless and broadband, as well as on fixed-mobile convergent solutions.

In many cases, the speeded up info-communication developments result in that the actual specifications, standards, norms, software and hardware elements backing up the designated technical trends, are available on the market in their 'half-made' status only that presents itself for the service providers as a significant risk factor concerning the product developments. This uncertainty factor can be efficiently reduced, if a provider has a particularly strong knowledge basis and a panel of open-minded and innovative experts, who are capable to well prognosticate how and when the half-made solutions appearing on the market will be completed. Keeping these viewpoints in eye, we are continuously searching for and monitoring those innovative and perspective technical possibilities, the application of which in our own network is worth for consideration.

In the first part of our Report we give an overview on the R&D activities performed in project themes necessary for the achievement of the strategic goals of Magyar Telekom Group. A special chapter is devoted in the Report to the Group's activities pursued in domestic and international R&D consortiums. Thereafter, we introduce in general terms our R&D activities related to other fields and - with some specific examples - illustrate how the results and knowledge materials obtained via R&D are utilized in our daily business. Our relations with and activities in the various domestic and international organisations are also highlighted. Finally, we present some key financial indicators of the Group's R&D activities and draw up our future plans and ideas.

Research and development activity of Magyar Telekom Plc.

Overview of R&D activities

Our research works aiming at the creation and implementation of new platforms and introduction of the future's convergent network we rank among our most important R&D tasks. With the appearance of Next Generation Networks, the importance of unified messaging systems has increased. End users can reach the telecommunication services via using different terminal devices and the wish of not having to have manage the incoming messages on different systems has occurred at their side as a justifiable demand. Putting telecommunications networks on a common platform has opened the way for efficient implementation of unified messaging systems.

A growing portion of Magyar Telekom's revenues is coming from data communication networks or relevant solutions. Among others, providing wireline and wireless Internet access, implementation and operation of virtual private networks of various levels, as well as carrier network solutions, etc. belong to them. These solutions are common from that point of view that all require higher bandwidth (or in other terms higher speed) for being introduced. The developments pursued with the aim of increasing the bandwidth have also the purpose of establishing the conditions for the introduction of further future-proven services. In the followings we give a summary overview about our activities performed for the realization of the said objectives.

Introduction of new network platforms and services requires new methodology in planning. At the further development of our planning methods we endeavour to put such planning, engineering and testing methods at disposal of Magyar Telekom that both from technical as well as from financial point of view efficiently support the optimization of the networks of Magyar Telekom.

In the interest of achieving of the above described objectives, we have determined the traffic parameters and characteristics of various voice and video transmissions applied beside Internet traffic and have elaborated the traffic model, the descriptors of IP core networks suitable for the servicing of 3Play traffic and the methodology of their reliability analysis. We have investigated how the methodology of creation of IP/MPLS network topology can be applied in multi-vendor environments and the extension of relevant traffic engineering and system technical planning methods to aggregation Ethernet networks. Transport network rearrangements, platform consolidation were also subject of our analyses. Furthermore, we have developed a methodology for the planning support of introduction and operation of fully optical networks. We have performed the reliability analysis of the national TDM-based transport network and pocket switched aggregation networks.

We have elaborated a methodology for the system technical designing and traffic analysis of GPON solutions.

In addition, we have performed test measurements with the purpose of analysing the applicability of high speed signals in the DWDM backbone network.
In connection with mobile network developments we have analysed the quality aspects of high speed mobile data transmission and have dealt with the streaming type services. We have performed tests for laying down the grounds of product development and have studied the international practice of the regulation of mobile network market and the trends to be expected.
In the interest of enhancing our knowledge management activity and the level of training programs, the Company Group is actively involved in the elaboration and as well in the realization of various research programs. Our co-operations and contacts maintained with domestic media and communication researchers and research centres are important requisites for the performance of these tasks. Practical problems and experience taken from various industries, or university, theoretical research works and innovative development projects related to them, are subjects of social/sociological researches. Primarily we have studied the social impacts of Internet and mobile technologies and content delivery services, and the new ways and means of their (community) applications.
Moreover, in the interest of preparation of acquisitions we have also analysed the local cultural characteristics of existing or future acquisition areas.
In addition to the themes highlighted in the previous, we have performed R&D activities in several other fields, too. These research themes are far-reaching and cover diversified professional fields. A brief report on them is given in Chapter "Further Research and Development (R&D) tasks".
Magyar Telekom Group consciously makes efforts to replenish or multiply its existing - both professional or financial - R&D resources. In the interest of it, besides involving external resources based on bilateral contracts and agreements, with our partners we have joined also such state-financed R&D projects, the results of which can be in short- and middle-term directly utilized. Foundation of R&D consortiums offers excellent opportunities for the involvement of additional resources. Further on we consciously endeavour for being actively involved in such consortiums, where the results support Magyar Telekom's infrastructural and service developments and the Company's employees to enrich their professional skills. We report on our activities performed in consortiums in Chapter "R&D consortiums".

To be able to keep pace with the evolution of telecommunications and IT, our developers have to possess always up-to-date professional knowledge on the novelties appearing in the field of electronics, telecommunications and IT. Therefore, we attach great importance - both in our national and international relations – to the various forms of direct exchange of information and experience. We maintain close co-operative relations with universities and research institutions. Magyar Telekom is member of the Scientific Association for Infocommunications Hungary, the Hungarian Association for Innovation and the Hungarian Standards Institution.
As to our international relations, Magyar Telekom has been a member of the European Telecommunications Standards Institute (ETSI), the International Telecommunication Union (ITU), a shareholder member of the European Institute for Research and Strategic Studies in Telecommunications (EURESCOM) and has been taking part in the work of DSL Forum. We have development co-operations with the member companies of Deutsche Telekom Group.
We share with and disseminate for the interested parties the knowledge and the results achieved by the elaboration of R&D themes on workshops and on 'PKI Scientific Days', the traditional conference event of PKI Telecommunications Development Directorate of Magyar Telekom Plc. In addition, we utilize the above in product developments, in tendering and equipment certification procedures and in O&M support.

NGN-based developments

Seeing the development of info-communications market it can be stated that the gaining grounds and spreading of NGN networks, as well as of pure IP based telecommunication systems are part not only of the strategy of Magyar Telekom, but of the international trends too. Envisaging it, Magyar Telekom during 2006 has launched nine NGN-related R&D projects, many of them dedicated to FMC (Fix-Mobile Convergence). Some R&D results are directly utilized in product developments, while others lay down the fundaments of later developments.

Applicability analysis of ENUM, an ENUM pilot system

ENUM is a technology, which rests upon the generation of DNS names from telephone numbers, whereas the DNS names orientate us how the called party can be reached. Our ENUM related research aimed at the investigation of the issue what kind of new services can be developed with the help of ENUM.
The study made regarding this subject matter discusses in details the methods of using DNS databases for ENUM purposes (dynamic update, frequent update, etc.). It analyses the ENUM client functions of SER (SIP Express Router) and the possibilities of its extension. It documents the configuration steps of the pilot system and the mode of connecting this system with the pilot system installed in the frame of Deutsche Telekom's (DT) TCC ENUM project. The setting parameters of the TCC ENUM IPSEC channel are also covered in the study. The experience can be utilised in connection with the introduction of IMS based products, since we have been using ENUM servers also in the pilot IMS call routing system. Our investigations facilitate the introduction of new, ENUM based services.
Thanks to the further development of IMS based NGN system, number portability and call forwarding/call routing based on telephone numbers rest upon a quite sophisticated, modern, cost-efficient and scalable solution.
The other study in the frame of this theme has been made as continuation of the proposal made at the end of 2005 for the introduction of ENUM and it serves as a preparatory material to T-Mobile's ENUM introduction plans.
In this second study - starting from the general features of ENUM - we have reviewed the international results, giving particular attention to those latest standardisation results and proposals, which have been achieved or made during 2006 in the ENUM Work Group of IETF. We have dealt with the analysis of the latest market news, vendor/manufacturer information and information obtained on various professional events.

Implementation possibilities of fixed - mobile convergence (FMC) based products

The purpose of the project was to extend the scope of tests commenced in the previous years with the provisioning of WiFi access. The research theme served the setting of the fundaments of Magyar Telekom's Dual phone product. Testing under laboratory conditions of promising technical solutions was an essential condition for the introduction of the new product.
We have tested two pilot (sample) systems. One of them is a VoIP WLAN network, which does not provide interruption free transmission, the other is an UMA system, which provides interruption free transmission. The WiFi network, which does not provide interruption free transmission, is indeed a normal WLAN access network, connected to VoIP servers. In our work, great emphasis was put also on the examination of the UMA system, which in its present form provides a unique solution for interruption free transmission. The only available UMA test system provided remote access to the centre of a company in abroad, thus we were not in a position to carry out server-side measurements on it. Getting closer familiar with the technology, we have got the picture that the UMA as it is could be applicable by mobile providers only, and for fixed line providers it is rather a threat.
Summing it up, we can state that in UMA environment the changing between technologies, i.e. the services resting upon fix-mobile convergence, can be considered as dead end solutions, thus in the future this research-development project should be reasonably continued with the purpose of finding solutions resting on real IMS based fix-mobile convergence.

Presence-based applications in fix and mobile environment

The summary study work made in the frame of this theme discusses in details the basics of IMS and provides a general overview on its structure and operation. It analyses the possibilities how presence and message handling can be implemented in IMS environment, and introduces (on protocol-level) some other services, too. On access side, GPRS, WLAN and UMTS networks are also introduced.
The WinCE and Symbian based VoIP prototypes have been prepared and we have tested them under laboratory conditions on two IMS systems.
The experience gained from interworking tests as well as

the thorough functional analysis of the presence based services we can utilize in product developments. Based on the results of the study, the presence based services become available for introduction in the network of Magyar Telekom by 2007.
The preparations for the interconnection of the IMS systems of T-Mobile and T-Com and for the introduction of common services are in progress. The technical fundaments for this have been laid down in two preparatory R&D themes.

Unified Messaging pilot system

The theme had the purpose to further develop the wireline MMS sample system implemented in the previous year, in the interest of making the system capable for handling or displaying on one graphical user interface of various kinds of messages in a transparent way.
In the course of the development we have created a sample system, which is capable to send, receive or handle SMS, MMS, e-mail, voice mail, video mail and fax mail messages. The system is able to handle the targeted types of messages via a web interface, which is quite similar to an e-mail manager. Each user has his/her own mail box, can freely manage, sort his/her messages. The system provides a transparent gateway function for handling the various types of messages.
The upgraded Unified Messaging pilot system can be connected to the IMS network of Magyar Telekom. In case of not realizing the further development of the pilot system, or its connection (to IMS) the experiences gained with the pilot will help a lot in the procurement of equipment with similar functionalities (for instance in the evaluation of T-Mobile's messaging RFI).

IMS application development platform

Our PSTN based IN system is coming closer to the end of its life cycle. For its replacement we have set the target to purchase such a NGN based intelligent platform (SDP = Service Delivery Platform), which besides further providing the existing PSTN IN services, also supports the introduction of value added services in Next Generation Networks (NGN).
The study summarizing the tests carried out in the frame of the theme, gives a detailed analysis how presence handling can be implemented in SIP (Session Initiation Protocol) based networks, particularly discussing the IMS-specifics of the issue. The prototype is an implementation of a presence and message handling server implemented with the purpose of protocol analysis. The server is capable to manage SIP-based connections or calls, as a stand-alone unit, as part of the BME test system, too. We have tested the presence server also with several clients.
The experiences of interworking, interoperability tests, as well as the comprehensive analysis of presence based services we can utilize in the technical planning, designing (and implementation) of Magyar Telekom's IMS based product development projects, enabling fast and efficient service development in IMS based Next Generation Networks.

Qualification methods in IP telephony environment

Guaranteeing the quality of telecommunications services in IP environment sets providers to a hard task. Originally, the IP network was developed for "best effort" type services, where the momentary network disturbances or congestions do not lead to greater problems. In case of quality telecommunications services, however, a greater deterioration of service quality is not tolerable. In the interest of optimizing the network and the bandwidth, it is necessary to determine the objective and subjective quality parameters of services (voice and video).
The theme had the objective of elaboration of qualification methods and creation of a qualification sample system.
The purpose of the study is to introduce the practices of quality measurement. The quality measurement sample system shall be capable for quality measurement using various methods, either under laboratory conditions or in the live network, too. Accordingly, the sample system shall be suitable for configuration and parameter setting.
In the course of the development we have thoroughly analyzed the quality measurement methods, algorithms for voice and video. We have prepared a quality measurement sample system, using which we can measure the changes in quality of video and voice files. The application is capable for managing or reversing IP, ISDN and PSTN traffic. The system compares the original and the distorted file according to the desired algorithm(s). The measurement system is freely configurable, thus it can be used not only in laboratory environment, but under live conditions as well. The measurement system includes a network simulation application, with the help of which we can analyze the various network faults and their effects, too.
The received results lay down the fundaments to select the measurement algorithm appropriate according to the task in question. The measurement system will play a significant role in the qualification measurements in Magyar Telekom's Next Generation Network.

IP-based voice communication in HotSpots

In the study paper written in the frame of this theme we have reviewed and compared the various VoIP protocols and the translation methods of the different (private and public) IP address domains, paying special attention to methods applied in VoIP environment (STUN, TURN, IC, RSIP, etc.). In details we have specified the functionalities of the SBC (Session Border Control) and the applicable

network scenarios. Then, the study described the configuration steps of Acme Packet SBC applied in the sample system, building up gradually, step-by-step the configuration used in the sample network. Then the correctness and accuracy of the settings have been controlled by measurements and test calls.
Based on the results of the R&D work the parameters of Magyar Telekom's WLAN HotSpots can be set in a way, so that the using of IP telephone service - for instance the Dual phone service - becomes possible.

Interworking analysis of SIP-H.323

The study analyses on protocol level the congruency of SIP and H.323 messages and their translation possibilities. In the test network we have used an Acme SBC (Net-Net SD), too, for the conversion of the signal messages and have carried out measurements on the test network.
With the tests we have investigated how the H.323 connections are handled. The test network contained two address domains, between which the only connection was the Net-Net SD. We used OpenPhone clients in the test. These clients can be free of charge downloaded from the web site of Open H.323. We used GNU gatekeeper, which is again free of charge downloadable from the web site. We initiated the calls after the two clients registered themselves in the core gatekeeper. Client 'B' used the Net-Net SD for the registration.
We have experienced that because of the great number of codecs the H.323 fast start setup message grew up so big, that the terminal and later the gatekeeper could forward it only in several portions. When such a message arrived in, the Net-Net SD dropped the package, so thus the call could not be set up. To eliminate the problem we have switched off the codecs in the clients, allowing only 2 or 3 codecs to be used. In this case the calls were successfully established and the media and signal messages were also successfully put through the Net-Net SD. The calls were successfully tested in both directions (SIP->H.323; H.323->SIP).
The experiences can be utilized in connection with VoIP systems of business customers (for instance regarding IVD and other - mostly H.323 based - services) and in case of customers connecting via newer SIP based networks using services resting upon IP-based interworking. The experiences enable development of new services.

Application possibilities of ISIM-based security solutions in convergent networks

In the coming years the market of mobile services will be dominated by three major groups of market players. On the other hand, regarding the services, with the appearance of IMS, further value added services become available - besides the today's well introduced basic services - for our mobile sets. The project had the purpose to survey those technologies, methods and procedures that can be associated with the various subscriber modules.
We have laid down our results in a study paper. The study first gives a cryptographic overview , making the readers familiar with the applied methods of DRM and the Smart card, what is an authentication element used in mobile networks and then with the applicable security protocols. We have described the cryptographic procedures used in IMS, mentioning also the ones used by ISIM. Then, the principles of smart card authentication were outlined. From the concrete protocols we have introduced those ones that are used by the system. Most detailed we have discussed the HTTP Digest Access Authentication and AKA solutions, since these are the central protocols of authentication taking place between the elements of IMS. Further, we have introduced the UMTS networks, the IMS, the structure and functions of the ISIM subscriber module from the perspective of the security solutions and the possibilities of their application.

Telecommunication services for users with disabilities

Reading words from the mouth, based on original image recordings of signal language interpreters, resulted in a recognition error rate of appr. 3%. On the analogue of it, we have designed such a communication aid for hearing impaired users, which somehow makes up the possibility of reading direct from the mouth during telephoning. In the system developed by us, we visualize the from reading from the mouth relevant parts of a moving/talking head model on a coloured graphical display. The control parameters of the moving/talking head are calculated on the basis of characteristics (feature points, FPs), directly derived from the speech signal. The head model controlled by the coordinates of the 15 Feature Points (FPs), if the controlling parameters were derived directly from the coordinates of the points marked on the image recordings of signal language interpreters, has produced a recognition error rate of 42%. Our experimental results have proven it, that it is possible to derive directly from speech signals such characteristics describing the moving of the mouth so accurately, what enables for hearing impaired people to perceive the speech with practical usefulness.
From the further improvement of the head model we expect that the whole system will improve so that a visual perception error rate below 20% can be achieved, which means in every respect an acceptable level.

Multimedia developments

Wireless access developments

The new point-multipoint type wireless solutions are necessitated first of all in the access, or secondarily in the aggregation networks. Thanks to the standardization efforts of the recent years, the 802.16 (WiMax) standard series have reached that level of readiness, on the basis of which manufacturer implementation can be started, what is a precondition of mass deployment and along with it of drastic decreasing of the prices of devices. The R&D theme has aimed at the analysing of the latest technologies, the determination of the conditions for their application and outlining the possible business models. In order to see the level of readiness for implementation, we have carried out tests not only under laboratory, but under real network conditions, too. The results of the R&D developments were utilized quite widely. Based on our tests we have introduced three WiMax based T-Com products: WiTalk, WiNET and IVD over WiMax. We have prepared the device specifications that has been attached to the WiMax tender as its Technical Annex. With the methods developed by the R&D work the network planners and designers could refine and further precise their results achieved so far regarding – among others – the interference, the Cyclic Prefix (CP) and the modulation change.
IP Radio has appeared to be a new research field. In the first step of the development work we have prepared a study paper, in which we have summarised the main characteristics meeting the voice requirements of stereo programme broadcasting and as well the signal transformation and coding solutions necessary for the later restoration of the required quality. With consideration to the network requirements of T-Com we have determined the possible mechanisms for the transmission of coded audio signal flows. We have presented the solution alternatives and characteristics of multicast based signal flow distribution enabling efficient capacity utilization.
Specification of the hardware and software requirements of a cost-efficient system prototype is part of this study, too. With the implementation in the practice of the specified system prototype the remote requesting (polling) of and listening to the various signal flows can be demonstrated. The results of the development serve as prototypes for the implementation of the radio service over IPTV and the outcomes of the study are utilized in the frame of the T-Home TV service.
In the pilot phase of T-Home TV service there were occasions that because of the cabling - which usually goes through the living room - interconnecting the Home Gateway and the Set Top Box the customers expressed their aesthetical concerns. The majority of the households does not have yet UTP CAT 5 cabling, even has not made preparations for that (with protective tubes). Therefore to eliminate this bottleneck, alternative network solutions have become necessary, for instance, the implementations based on radio technologies come into question as well. WLAN is one of the applicable technologies. Magyar Telekom has introduced it on the market several years ago. In case of T-Home TV service the availability of multicast and QoS support are fundamental requirements, besides the bandwidth provided by this technology.
The study written in the frame of this development on one hand works up the IEEE 802.11n Recommendation, which is yet under elaboration but support higher bit rate data transmission, and discusses the IEEE 802.11e as well, which has been ratified already and provides QoS support, on the other hand verifies with measurements the video and audio signal transmission characteristics and draws the conclusions for the individual cases.
The most important final conclusion is that in case if a device has not at all any quality guarantee mechanism, then purely the higher speed is not sufficient for the transmission of the T-Home TV service. On the other hand, in case of availability of appropriate QoS support (IEEE 802.11e), the support of the transmission is possible even at a speed rate lower by one category.

xDSL-related developments

From the point of view of the future of Magyar Telekom broadband Internet/IP access resting upon the ADSL technology is determinant, while the subscriber demands, the new product developments and the services to be introduced set more and more challenging tasks for the access network segment, where first of all the growing bandwidth demands need to be met.
The technological limits of early ADSL are well known in the circle of professionals, therefore the standardization bodies concentrate great efforts in the recent years for the provisioning possible higher bandwidths on copper pairs. The R&D theme had the purpose of determining the conditions and introduction in the network of Magyar Telekom those device features and capabilities that have been elaborated by SG15 of ITU-T and that meet the latest xDSL standards.
As a result of our work we could state that from the currently available technologies - taking also into account the specific conditions of Magyar Telekom - there are two pre-

ferred technologies: ADSL2+ and VDSL2. With ADSL2+ there can be higher than before bandwidth provided with limited coverage in case of DSLAM-s installed at MDF-s, while VDSL2 can be a basic system technology applicable in Cross Connect Cabinets.
Magyar Telekom has introduced ADSL2+ technology in its network yet during 2006. The manufacturers have implemented later than we expected the VDSL2 technology in their devices, due to the longer time needed for the standardization.
The ADSL based services and network developments required the implementation of new functions, too, in the network. Besides the fix monthly rated ADSL packages there is a growing demand for the cheaper services, which require less resources. One solution of it is the introduction of packages with traffic limitations. Here the abuse of user names providing unlimited access on a theoretically limited ADSL line appears as a potential economic/financial risk.
To prevent these abuses it is necessary to somehow associate the user name with the subscriber line, in a way that is universally applicable in case of every DSLAM supplier.
It means that not only the users need to be identified but the individual subscriber (user) endpoints, too. We have elaborated the technical implementation in line with standardized solutions for ATM and Ethernet aggregation networks.
The solution elaborated as the result of the development has been realized as a product in the frame of the NGS project. The full introduction will be realized in 2007 with the launching of "naked ADSL".

Virtual private network (VPN) developments

The R&D theme titled „Application of VPN-like technologies" deals with virtual private networks - that service first of all medium sized enterprises and large companies.
The R&D theme reviewed the evolution of the various VPN architectures, which are one of the most important revenue sources of Magyar Telekom in the field of data communications. In the frame of the theme there have been applicable and on the long run perspective solutions, as well.
These VPN-s may be of so called L" (Layer 2 of OSI) or L3 (Layer 3 of OSI) VPN-s. There is an extremely keen competition in the medium and large sized enterprise segment, therefore the provisioning of services with the possible widest scope on future proven technologies is a matter of primary importance. Specific solutions of certain new technologies (VPWS or VPLS) have been incorporated with a broader or limited geographical scope into the complex L2VPN product (Multiflex) of Magyar Telekom, or a new L3VPN solution (SSL VPN) is under elaboration as well. The studying has covered also the issue of the applicability of those solutions, which are known for a longer time, but which are used so far with limitations or are not used at all. From the OSI L3 VPN solutions some VPN-type have further on no perspective: as such PPTP can be mentioned, for instance, certain types are in use already (like IP Sec) but the extension of the field of application is not recommended for the time being. On the other hand the introduction of SSL-based VPN is now in the starting phase. A conclusion of the analyses and tests was that the application of PPTP for the purpose of complex L3VPN has been rejected, but L2TP will remain applicable for specific purposes (PPPoE aggregation).

Multimedia related broadband developments

In the recent three years multimedia related developments were one of the key important development areas being in the focus of our R&D activities. In this field we have launched a number of development projects to support our network and product developments. Utilizing our knowledge gained with the preparation of IPTV project, according to marketing requirements we have prepared a technical specification, on the basis of which the platform was selected.
To lay down the technical fundaments for the further development of IPTV product we have launched a number of R&D themes to improve the quality and profitability of the already working service. Among these themes one can find research works that focus on the intelligent subscriber terminal equipment (Set-top-box), the remotely manageable multimedia devices, efficient media contents distribution over IP or the studying of the usability of digital watermarks.
As a result of these R&D works we have developed , for instance, such video distribution techniques working on the IP network, with the help of which the volume of unicast traffic generated by Video on Demand can be reduced or transformed into multicast traffic, saving for Magyar Telekom from asset investments of even several millions in value. The results of the research concerning digital watermarking represent techniques, using which the media contents forwarded to the users can be individually marked. Namely, the digital watermarks mean information hidden in image or sound content, which remain hidden before the user, but the detector knowing the algorithm and the keys of the digital watermark can identify them.
Using the watermarks the subscribers become individually identifiable, thus in case of delivering copyright protected materials to unauthorized users the source of the leakage becomes identifiable as well. The research results may contribute to the improvement of the contents protection functions of IPTV.
By today a considerable part of Internet traffic is already p2p type traffic realized without a central source as network traffic of interconnected end users. The content providers should also pay attention to the possibilities implied in the p2p networks. With the increasing uplink bit rates, the users located close to each other or forming a closed user group may exchange with each other the various media contents more and more efficiently on the p2p platform. In the course of our developments we have investigated under laboratory conditions and using a prototype the possibilities of delivering p2p VoD contents.
Today contents delivery cannot be restricted to a single access platform. We have investigated the possibilities of future deployment of IPTV in the view of converging networks and adaptive video coding. We have focused on two issues, to find answer to the followings: on one hand, how video and voice contents can be delivered to non-stationary, or moving subscribers, who are using various media. on the other hand, what are the most efficient available practices for the resizing, trans-coding of video contents. With the help of multi-platform media services in the future 3Play may become available on mobile sets, on PDA-s, or even on notebooks. Researches show that the appearance of scalable video coding as expected in 2007, we to a great extent promote the extension of the network and the IPTV platform.
Besides quality and efficiency, regarding the popularity of a service, security, too, might be a critical factor. Leaked away media contents increase the circle of illegal users who do not pay for the service. However, security cannot be applied without compromises. We have set to analyse the impacts of extra delaying of encrypting algorithms and bandwidth increases, and the first numerical results measured on a prototype we expect by 2007.
Acceleration of the provisioning process was a demand raised in the course of the implementation of the IPTV project. To achieve this goal, we have examined the possibility of remote supervision, management and configuration of terminal equipment installed at customer premises. As a result of our research work concerning remotely manageable multimedia devices, we have drawn up CPE specifications according to TR-069 and TR-111, on the basis of which we could prepare the Technical Annex of the Multi Device Management tender. As a result of the tender we selected the most appropriate system to meet the demands and this system is currently used for the provisioning of endpoints for our 3Play (and then our 2Play) product.

Development of network design methods

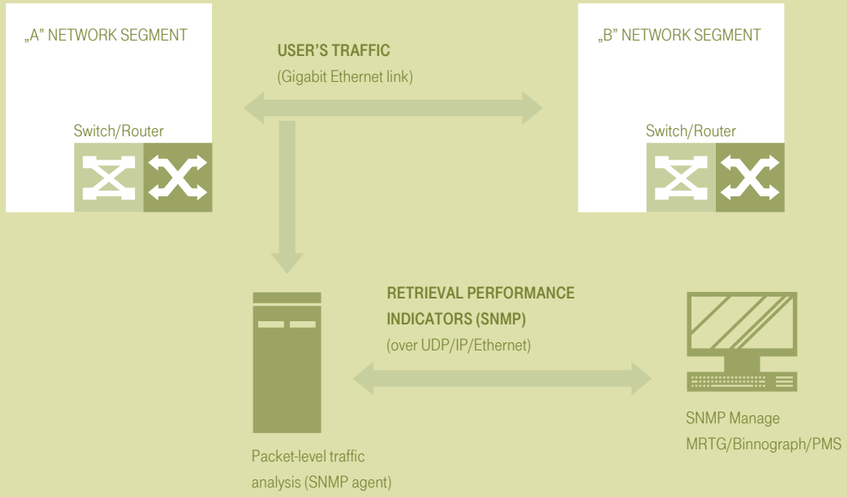
Determination of traffic characteristics of various voice and video applications transmitted beside Internet traffic with the use of packet level measurement data

In the frame of the research theme we have developed a complex measuring-monitoring method, with the help of which the statistical characteristics of voice, video and internet applications transmitted via a given IP network link can be determined. In case of GE (Gigabit Ethernet) interface, the measurement and data processing method developed for packet level data collection is capable to provide quasi on-line statistics upon the traffic going through the interface at the same time enabling accessing to the data for displaying them on graphical user interface (GUI). The data obtained by the method provide information on the performance capabilities of the network and they can be used in the dimensioning, engineering of the resources of T-Com's IP/NGN network. The figure below shows the topology used as a test bed for the measurements.

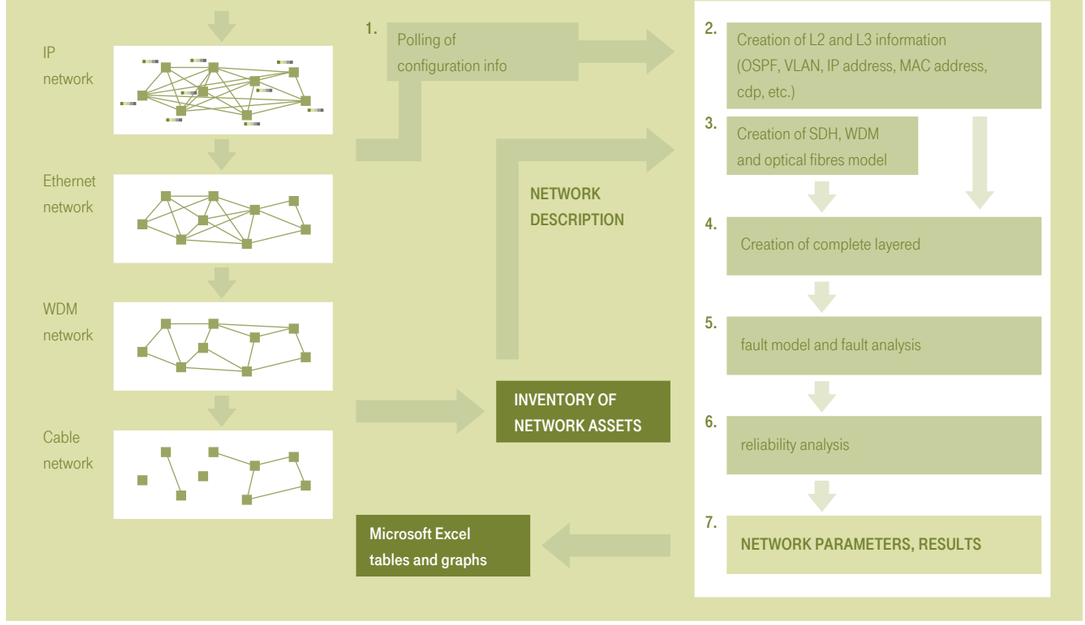
The scope of the statistical survey based on the analysis of the RTP and TCP/UDP headers has covered the volume of voice and video traffic, their portion from the total traffic, the packet loss, the distribution of packet delay and the packet delay jitter, as well as the hop number analyses. The developed application provides the possibility of user-friendly configuring on a Graphical User Interface (GUI) of the monitoring and is capable to display certain statistics produced from measurement data also in numerical form. We have validated the method with the assessment of the data of passive measurements carried out on the IP network of T-Com.

Moreover, we have developed a new methodology for the identification and analysis of the Skype traffic. The identification method is based on stream-dynamics, which identifying the signal traffic enables the identification of computers running the Skype client and of the voice traffic as well. Using this newly developed method we can obtain more exact information than with the methods used in the past on the portion and volume of Skype traffic.

Measurement test bed topology for traffic statistics purposes



Process of reliability analysis



Elaboration of methodology for traffic modelling and reliability analysis of IP core networks suitable for servicing 3Play traffic

From 2006 on, besides Internet, more and more services, demanding as basic requirement higher network availability than before, have been using the IP network of T-Com. 3Play service implementing both voice and video signal transmission, the interconnection of cable television head end stations over IP, the introduction of new type broadband business communication services, the government services are of such kind of services having these demands. The aforesaid services, the integration of the IP networks of T-Mobile and T-Com as well as the future replacement of traditional telecommunication networks necessitated the development of "carrier grade" quality service IP network. For the planning of this network our former planning tools are not yet sufficient, the traffic engineering shall be expanded with reliability planning and analysis functions covering all and every network layers.

We have elaborated already earlier a method for the traffic and reliability analysis of the operating IP network of T-Com. In 2006 we have extended the method to the modelling of the planned IP network, too. For this work, we have set out in tabular form the information determining the IP devices and routing options. We have supplemented the methodology with the inclusion of the present and planned WDM transport layer into the model in a way, so that we can take into consideration the eventual failures of the WDM devices during the reliability analyses. We have associated the network elements with reliability parameters and for each and every traffic relation we have determined the availability of the individual possible routes. The process of the reliability analysis is illustrated on the above figure.

It has become possible with the help of the method to qualify the expected availability of the services available on the network for the various protection solutions. In addition, the weak points of the network from the perspective of network reliability have become detectible as well. Besides the point-point traffics we have elaborated the method of the modelling of multicast traffic, as well. Thus, when planning the network capacities we can take into account the impacts of the components of this kind of traffic as well. In addition, we have developed a traffic and reliability method, too, which is able to handle several various traffic classes.

Elaboration of methodology for the determination of traffic descriptors of IP network

We have elaborated the theme with the purpose of developing such a methodology, with the help of which the input data required for the calculation of the packet-level traffic characteristics can be determined. We have elaborated the method for the calculation of packet-level traffic descriptors in the frame of another research theme. The method developed in the frame of the research theme allows the assessment of those IP network traffic statistical characteristics and parameters, which serve as required input data for the mathematical and simulation techniques developed for the determination of traffic performance capabilities of existing (real) and future (planned) IP networks. The information gained with the method we utilize in traffic performance capability analyses documented in IP network development plans.
The traffic descriptors (characteristics) required for the planning of the QoS (Quality of Service) performance of IP networks can be determined by adequate processing of traffic measurement data. For doing this work during the elaboration of this task we have developed a methodology which is suitable for the statistical description of the aggregate traffic of various traffic classes. As part of it, we have developed a method for the separation of traffic components requiring special quality and techniques for the evaluation of aggregate traffic statistics, among others with special regard to time scale of data processing, the measurement-evaluation periods and the extent of aggregation.

Method for the creation of IP/MPLS network topology in multi-vendor environments

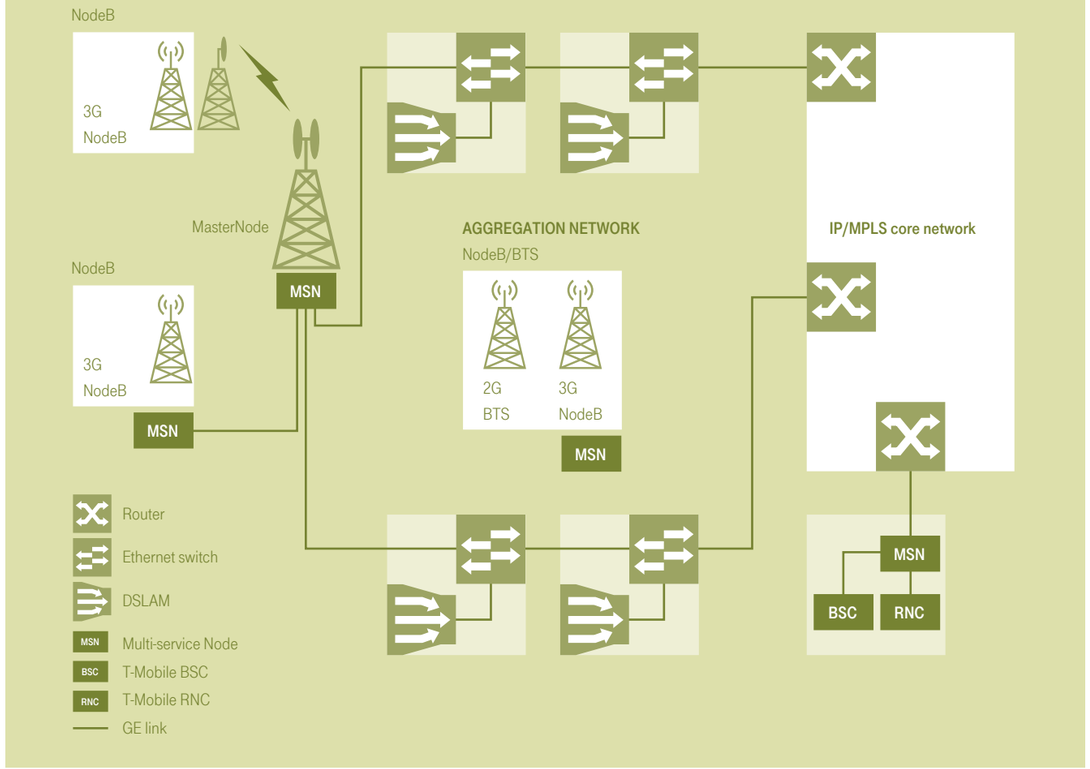
In the frame of the theme we have developed a method, using which the model suitable for the traffic and reliability analysis of T-Com's operating and planned IP network can be implemented. During the making of the model of IP network, the data of IP devices and their interface cards have been retrieved from the configuration files of the equipment, while the route information of optical cables from the network inventory. So far the topological model of the IP network for the purpose of creating the actual IP network's traffic and reliability model was exclusively created from the neighbourhood (adjacency) information detected by „Cisco Discovery Protocol". This method has, however, enabled the making of the network's topological model only in case of homogeneous networks, consisting purely of Cisco devices. In a multi-vendor environment, it is more practicable and reasonable to apply the information available in the network inventory systems and supplement these with information retrievable from the devices themselves. This new method enables the modelling of the IP network of T-Com also in the case, when in the future there will be devices also of other manufacturers installed in the network.

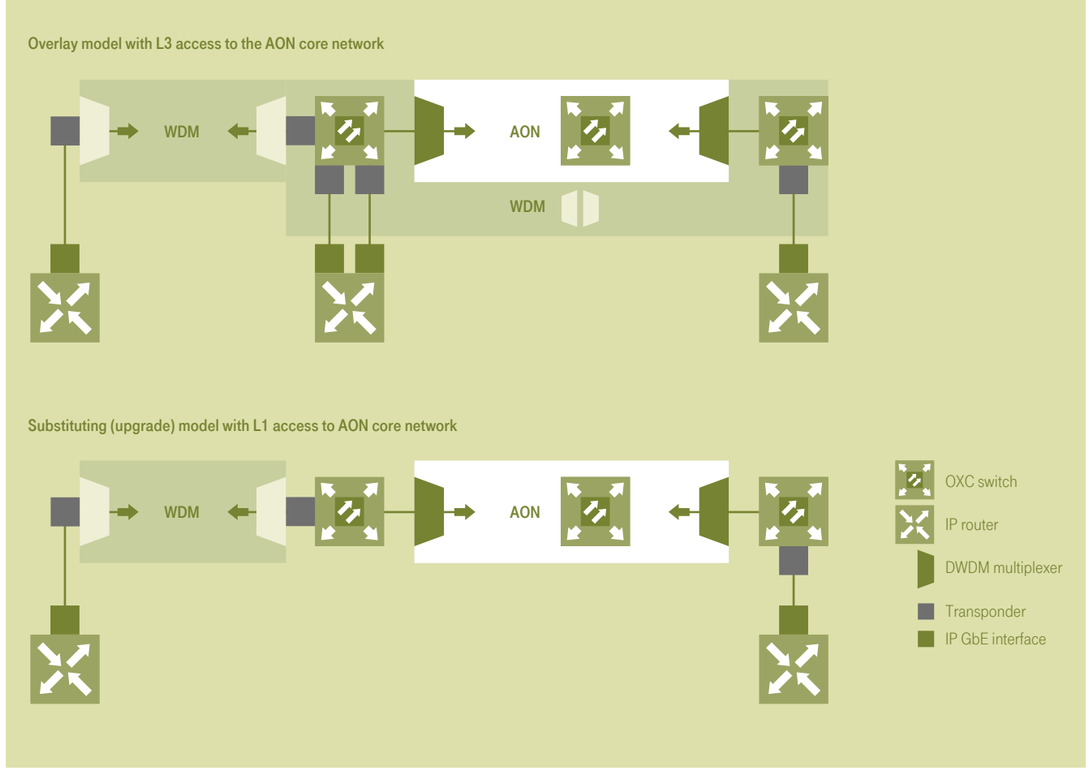
Extension of traffic engineering and system technical planning methods to aggregate Ethernet networks

The integration also from technical points of view as much as possible of fixed and mobile segments is one of the strategic goals of Magyar Telekom. The basic motive for the elaboration of new planning methods and plans was the intention of establishing the possible highest level of harmony between the actual large-scale UMTS network extensions of T-Mobile and broadband extensions of the fixed network of Magyar Telekom. This has covered first of all the implementation possibilities of optimized construction of new (microwave or optical) physical connections in the aggregation network layer and implementations of common transmission technical solutions resting upon the said connections. Using the XPLANET planning system there have been the followings elaborated:

- Determination of a traffic model based on the available fixed and wireless resources, as well as on voice, data and mobile service demands to be satisfied with the future common network infrastructure.
- For physical level planning activities establishing a connection between the graphical inputs (mostly AutoCAD based maps) and the network model.
- Analysis of initial network alternatives based on the traffic model and present network structure.
- Determination of traffic engineering, traffic dimensioning methods to be applied.
- Elaboration in details and analysis of short-term development alternatives.

Applying the elaborated network model, for better practical utilization, the plan takes into account as a basis the existing physical network structures of T-Com and T-Mobile, as well as the anticipated geographical extensions forecast till 2009 on the basis of traffic estimates provided by both areas. As a result of the plan, it has been proven that analyzing the various reachable points of the two segments (fixed and mobile) a considerable part of optical cable constructions (110 km length) can serve common targets and consequently altogether can lead to much cost-efficient solutions.
Following the planning of the physical layer we have elaborated common transmission technologies on the basis of which the alternatives of development plans have been prepared, which take into account the traffic forecasts both of T-Com and T-Mobile. Common and optimized use of the existing and in the future built transmission network infrastructure results in the use of less system technical elements. The Ethernet based common system technology is shown in the following figure.





We have analyzed the planning results also from the perspective of costs, too. It has become clear, accessing of which points is realistic with optical fibres and which points could be solved with microwave links or location of which points should be reconsidered.

Rearrangements in the transport network, platform consolidation

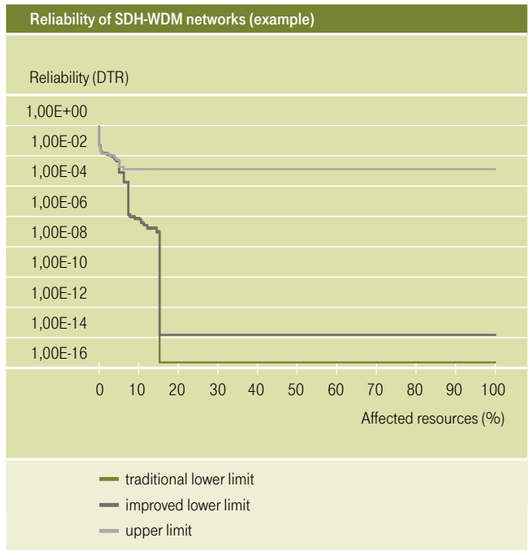
Based on the summarized experience and conclusions gained from the work started in 2005 we have laid down the planning guidelines and methodology for the optimization and technological consolidation of the whole backbone network and of Budapest Junction Network (BÁH). Then, the prepared network plan has been analyzed in details in terms of the quantity of the rearranged connections, the changes in alternative routes and their reliability, as well as the network capacities.
In our work we have set a high value on the target that the planning results of a rearranged segment appear along with the information obtainable about the existing or planned systems in a uniform and consolidated manner for the planners of the planning segments concerned.

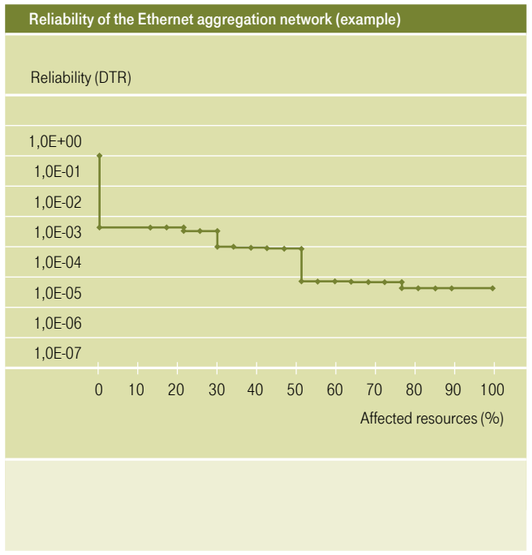
Planning support of the introduction and operation of pure optical networks

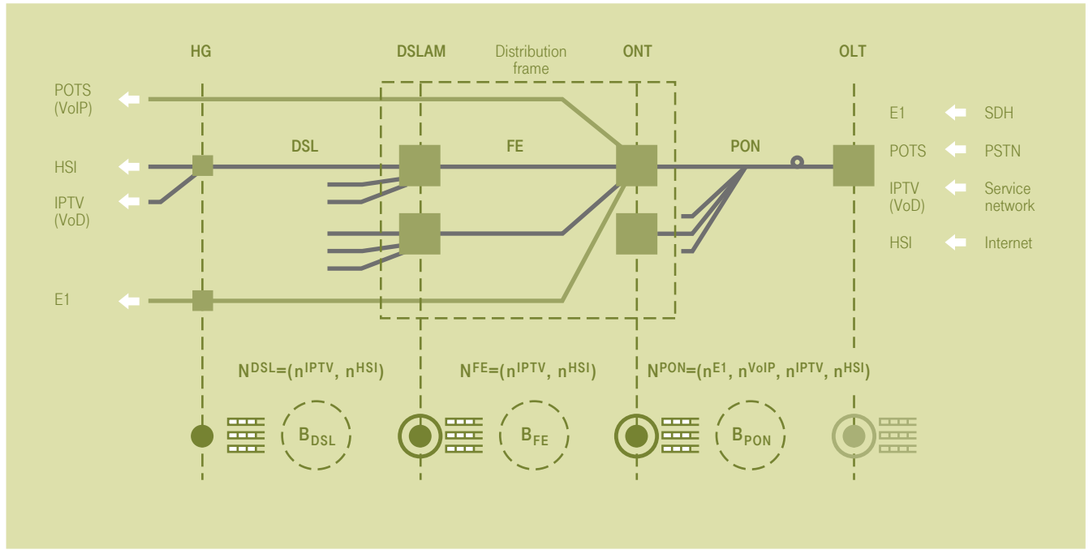
The research-development theme had the purpose of outlining the topology and system technical solutions of a transparent optical network overlaying the backbone network (penetrating even up to the county seats) and giving an overview of the possible implementation scenarios of such a network.
The study provides an analysis of possible scenarios for the future introduction of a functionally rich optical core network, and with the results and conclusions drawn based upon the analyses it contributes to the decision-making preparatory process in connection with the implementation of a pure optical network layer. On one hand it describes the possibilities provided by the existing optical cable network of Magyar Telekom and the already available or soon appearing devices, implementing pure optical network functions. In addition, starting from the requirements related to the dominant IP-client logical topology it evaluates those variants, which can be implemented with the application of high speed (2,5 - 10 Gbps) optical transmission systems.
The figure above shows the overlay and substituting network model.
We have accomplished the analysis of the „WDM upgrade" version, i.e. of the finally targeted future network architecture, too. In the frame of this work we have determined the number of optical transformers used in the network (which is a cost-relevant (cost proportionate) characteristic of the network), the analysis of the reliability of network level connections, as well as of transmission performance and network protection. Based on the analyses we could state that with the given IP traffic assumptions the networks consisting of purely optical elements satisfy the occurring transport demands with higher reliability, while using less transponders.

Reliability analysis methods concerning national TDM-based transport networks and packet switched aggregation networks

The theme set it as a goal to further develop with a uniformed approach the reliability analysis methods applied on telecom networks and the modelling and analysis functions implemented in the XPLANET planning tool and to extend those to WDM networks for the supporting of the analysis of SDH-WDM technological architecture and Ethernet-based aggregation networks. As a result of it, we have elaborated such a detailed modelling technique, which rests on the reliability data of network devices and is applicable for the analysis both of existing, or future, or combined (existing and planned) networks.
The results achieved can be split into two parts. Regarding the SDH-WDM architecture, in line with the layered modelling approach of XPLANET, there have been reliability models produced with parametering based on the equipment data. Thus the existing of the planned networks can be uniformly handled during modelling. As to the reliability models we have applied the reliability models and analysis methods







of the unprotected SDH networks, the SDH networks with 1+1 dedicated path protection and those of WDM networks equipped with optical channel protection.
Regarding the Ethernet-based aggregation networks, we have prepared the reliability models and analysis methods of planned Ethernet-based aggregation network, or of those described with the configuration files of the switches. These models and methods have been prepared both for redundancy free and as well for redundant network topologies. From the network parameters generated during the reliability analysis there can be the downtime ratio of point-point demands, the network level performance index and the availability curve analysed. The figures above show the reliability of SDH-WDM and Ethernet-based networks. The developed sample software programs are suitable for the description and analysis of the planned network or also for the analysis of the planned network over the existing network.

Elaboration of methodology for system technical planning and traffic analysis of GPON solutions

Magyar Telekom has been providing its broadband services more and more extensively and comprehensively. In the near future the services, like high speed Internet and IP-based TV, requiring the multiple of bandwidth required today will definitely come to the limelight in the broadband service portfolio. From the point of view of the broadband services or network planning, the most critical segment is the access network segment. The known limitations of the copper-based access (ADSL, VDSL) can be overcome only if we extend the optical network and bring it even to the subscribers. In the recent years there have been several optical access network solutions developed. These are used to be mentioned with a common name, as FTTx network, whereas in the abbreviation of Fibre-to-the- x (FTTx) the "x" may refer to street cabinet, to building (FTTB), or to flat, depending on how far the optical network is extended.
The passive optical network (PON) solutions have primary importance among the optical technologies applied in subscriber access networks. For the assurance of the appropriate service levels, we have analysed the issue how the passive optical systems with gigabit capacities could be introduced and applied. In the first step we have modelled the expected subscriber demands and the service profile. The table below shows the volume of expected traffic generated by IP-based voice transmission, video image transmission and fast Internet, depending on the encoding.

	Traffic	Encoding	Max. speed	Priority
VoIP	ON-OFF CBR	GSM	34,8kbps	high (1)
Video	rtVBR	MPEG-2/4 3/4 PAL	4-6Mbps/2-3Mbps	medium (2)
HSI	UBR	x	4/2Mbps	low (3)

There can be different priorities associated with the individual traffics, depending on how much the given service is sensitive to transmission speed fluctuations or to the delay. For the traffic and QoS analyses we have built-up a service model, as it is illustrated above.
Further analysis and simulation of the models took place in the OPNET system. We have analysed the functioning of the algorithms enabling dynamic bandwidth allocation (DBA) and the QoS parameters of the system too. These have been evaluated with the help of different sample configurations set up during the traffic modelling. In parallel, we have also performed the analytical testing of the system's traffic behaviour, providing approximation solutions for the calculation of the necessary multiplexing and system capacity values.
Using the results of traffic analyses and visualizing the sets of demands graphically or on a map, we have produced the prototype of the system technical planning tool supporting the planning of GPON networks. The prototype is able to give the optimized optical access in case of sectored demand sets given in green field network construction projects and for these routes to give the vendor specific parameters for a passive optical system, providing FTTB solution. In addition to the GPON analyses we have performed the measurements of the basic parameters of a vendor sample system, too.

Analysis of DWDM backbone network

For the purpose of analysis based on concepts and practical measurements of the applicability of high speed signals in DWDM networks, we have implemented the detailed simulation of the WL3 segment (Székesfehérvár - Veszprém - Taliándörögd - Keszthely - Zalaegerszeg) of Magyar Telekom's DWDM network. We have carried out measurements, as well, in order to control the results of the simulation and we could state that the measurements in the most part verified the results gained from the simulation. Based on these results, we have made propositions for the optimization of the said segment. The optimization in this case means that amplifiers and regenerators can be omitted with the benefit of cost savings and improving the reliability and availability parameters of the system.
Based on the results of the work it can be presumed that concerning the WL3 segment, the amplifier in Taliándörögd and some amplifiers in Keszthely can be omitted. Similarly, the same applies to some regenerators installed in Székesfehérvár, too. The results of the theme can be confirmed with additional measurements and service tests performed with the utilization of free wavelengths available on the segment. If these investigations and analyses conclude with the expected positive results, the planning or designing the eventual network reconfigurations may come into question. In view of the results other bigger WDM nodes can be revised as well. In these places in the interest of the eventual optimization Q factor measurements shall be performed. Depending on the results – ensuring the required margins – the optimization of the network node equipment can be performed.

Mobile network developments

Quality issues of HSDPA networks

The quality of High-Speed Downlink Packet Access (HSDPA) networks is characterized by the maximum transmission rate the users can achieve and by the average speed that can be realized in the cell. The impact of various network parameters on HSDPA is interpreted on the basis of the signal-interference ratio. The use of the Channel Quality Indicator (CQI) essential in HSDPA and the way to identify it can be determined based on this ratio. As a result a proposal on a simple method is given, suitable for analyzing the interaction between the „traditional" UMTS traffic operating according to Release 99 and the HSDPA traffic.
In the other part of this work an overview is given on a few setting issues of R99 and HSDPA radio networks based on the currently effective standards and concrete questions encountered in planning practice are answered.
In addition, an analytical packet switched data traffic model with which data communication services can be scaled in the HSDPA network will also be described. Based on this and on previous findings we have surveyed the issue of planning HSDPA load and analyzed the possibility of setting independent HSDPA carrier frequency as well.
With a view to achieve better radio performance the smart antenna systems will presumably gain ground in the near future also in public cellular networks. Thus presumably MIMO and adaptive antenna systems will be the next step as regards the optimization and capacity upgrade of radio networks. The fundamental principles and application possibilities of smart antenna systems were studied so as to lay the theoretical foundations of such tasks.

Impact analysis of mobile market regulations

The purpose of the subject was to examine the impacts of regulatory measures concerning mobile carriers. In the frame of these efforts we have compiled a study dealing with the essential issues of mobile regulations where – as a supplement to the previous paper on the subject – the effects of various regulatory measures are analyzed; therefore the present work may be considered as a continuation of or completion to the analysis of last year.
The study dealt with three main areas of regulations concerning mobile carriers. Since no sufficient information is available to make possible the quantitative measurement of impacts on market players, the main effects are described using a qualitative approach. In the first part of the study the consequences of regulations on mobile termination and the assessment of such consequences are discussed. The second part deals with the background and the expected consequences of the European level assessment of and recommendation on regulations currently in process concerning international roaming charges. Finally a short overview is given on arguments made and experience gained in connection with the regulation of Mobile Virtual Network Operators (MVNO).

International practice and experience concerning the regulation of the mobile market

The purpose of the subject was to analyze the regulatory practice on mobile termination, mobile access, call origination (wholesale service allowing the appearance of MVNOs) and international roaming based on economic and regulation theory basic principles on which the new regulatory framework of the European Union is built.
The study compiled in the frame of this subject surveys the role of regulations in the various phases of mobile market evolution, then describes the milestones of European mobile regulations, the changing of philosophy on regulations as well as the reasons for such changes. It describes in detail the main features of mobile market regulation in the regulatory framework applied in 2002 within the European Union (and for the time being in Hungary) then theoretical considerations encountered in international technical literature on the subject – made in connection with potential competition problems of the mobile market and the applicable regulation – are discussed. The study shows how the economic arguments and relations appearing here may be applied by the regulatory entities and the service providers. The authors of the study deal with the practical implementation of European regulations, present the results of market analyses carried out by individual authorities and finally survey regulatory models outside Europe as well.

Researches on streaming

With the rapid development of wireless communication more and more as well as better and better services become available on mobile networks. Today the real time transmission of audio and video signals to mobile sets (watching TV on mobile) is no more a problem and in the course of a call the transmission of pictures can also be realized in addition to voice communication. Nowadays a mobile set is already a facility for everyday use thus the multimedia possibilities (picture and video recording, Internet access, interactive communication) are available for anyone, at any place and at any time.
Taking these changes into account a simple mobile set also can be suitable for the satisfaction of interactive multimedia demands, within the limits of its size. The purpose of the research was to map out these restrictions and/or extend the limits so as to make mobile multimedia terminals capable of replacing the individual targets and previously proved procedures of television channels as well as exploiting new opportunities.
In the course of research efforts we analyzed – first of all from cost reduction and time saving aspects – the possibility of applying mobile technology for live transmission from the venue of events, and examined how the interactivity of viewers can be extended in various programs using video call service.

Mobile purchase

The purpose of the subject was to identify the development trends to be followed in the area of mobile purchase and payment. During the research the issue of mobile payment and mobile purchase was handled separately; in the former case a quantitative research using questionnaire was made, while the problem of mobile purchase was investigated based on qualitative conversations with focus groups.
During the focus group interviews we basically wanted to find out what service development trend is proposed by students as a specific segment. In order to trigger the brainstorming session we analyzed the association of students concerning cash and mobile purchase, applying projective techniques. In the following the expenditure structure of students and their preferences relating to the way and location of purchase were mapped out.
In the target group several topics were discussed to find out to what extent the mobile purchase service is known by members of the group. In the possession of the information gathered we can outline the limits and opportunities of spreading the service within the target group, and taking into account the criteria of the target group specific killer application and the ideas of those participating in the survey we made concrete proposals as well.

Mobile music center

The purpose of the subject was to identify expectations concerning the utilization and content of mobile music center service and to examine the willingness of current and potential users to accept prices.
In the course of the research current and potential users were handled separately; the opinion of the former subscriber base was asked in the frame of qualitative focus group talks while the latter group was interviewed using quantitative questionnaires. The main question raised in focus group talks was to what extent the active users of mobile music center are satisfied with individual components of the service. In order to become acquainted with their music related attitudes we first mapped out their music listening patterns, then concentrated on aspects of overall judgment on mobile music center service. We explored the positive features, deficiencies and potential development areas became known during the use, then analyzed the underlying reasons for the trend of satisfaction.
In the course of quantitative research the general habits concerning music listening and mobile usage patterns which can be considered as the basic condition of mobile music download were measured first of all. We also attempted to find out how this service would be accepted by adults living in Budapest (18 to 60 years old), what is the probability of their using it, what amount of money they would be willing to spend on it, what supplementary services would be requested by them and what kinds of promotion they would prefer.

Research the development possibilities of new products in the area of mobile phone content service

Content providers shall meet everywhere in the world new economic, social and cultural requirements. Therefore it is essential for the companies to be able to cope successfully with the newer and newer challenges of the society. In accordance with this basic requirement Magyar Telekom also investigates on an ongoing basis the possibilities of developing new products in the area of content service.
In our research tasks we examined:

- what new mobile advertisement solutions are received favorably by the market,
- how the ratio of those using WAP can be increased,
- what already existing mobile advertisement solutions are worth being introduced on the market,
- whether it is expedient to implement social networking sites in mobile environment and if so, what functions should be taken over.

While elaborating the subject various consumer groups were targeted and average mobile users were also asked to express their opinion and ideas. The outcome of the survey shows that:

- there is demand on the market for new services,
- as regards the mobile advertisement solutions consumer demands not recognized or identified previously can be detected,
- some consumer groups would receive favorably the mobile version of a community site (IWIW),
- according to the technology and mobile phone penetration the acceptance of WAP cannot be considered as satisfactory; the reason is partly the customer attitudes and usage habits, but it is also correlated with the price-value ratio.

IPv6 in the mobile networks

The unbroken success of Internet can be attributed to a great extent to the extraordinary capability of the TCP/IP protocol family on which it is based. During its practical operation of nearly two decades the TCP/IP was able to serve in an almost unchanged form a network where the number of users and devices connected to the network

was multiplied meanwhile by several ten thousand. The aim of our research was to examine the applicability of IPv6 protocol in mobile environment.
Following the general description of IPv6 protocol the study prepared in the frame of the subject investigates the mobile network aspects of the protocol and specifies its impact on the various levels of mobile network environment. It is established in the paper that the current stage of IPv6 development already reaches a level in many areas where – leaving the frames of experimental networks – it can be introduced in operating (live) environment as well.

Multicast in the mobile networks

In a wider sense two types of transmission technologies applied in packet switched communication networks can be differentiated. There are networks based on point-to-point links and networks based on datacasting (that is on point-to-multipoint links). In a two-point network (unicast) the connection between two computers is set up from point-to-point links therefore in such systems if we want to deliver a packet to the addressee then the message is usually passes through several intermediate stations as well.
In case of datacast networks there is a common communication channel which all the computers have to share. When a terminal equipment sends a message it is received either by all other terminal equipment of the network (broadcast) or by the terminal equipment forming a given group (multicast). The sender and the addressee can be given in the header of the packets thus a given computer is able to decide whether it requests the packet or not.
In the frame of the subject we have examined solutions offered by mobile networks developed or upgraded with broadcasting purposes. Such are for example the MBMS and BCMCS68. As a result we can establish that MBMS supports both broadcast and multicast based broadcasting. The main purpose is to extend mobile content service and to create the technological conditions needed for new media services (mobile TV, mobile news service). In addition, it is also destined for solving certain economic and technological problems connected with new generation wireless networks (radio bandwidth, economizing on natural resources, replacement of the wasteful method of point-to-point transmission, etc.).

Sociological researches

Examine the sociological aspect of mobile communications

The target of the research was to sum up mobile – sociological surveys and analyses carried on all over the world since about 2000, particularly analyses conducted and organized in Hungary from December 2000. The collection of new prospects which may be prognosticated on psychological, pedagogical, sociological and philosophical levels according to the current status of mobile studies under the conditions of telecommunications convergence was also an objective to be achieved.
The results of the research clearly showed that a certain transformation of social sciences – the adaptation of social sciences to the mobile world in terms of content – emerged by 2005 at the latest and became obviously irreversible by now; on the other hand an independent research direction which has more and more an own paradigm came into being – this is mobile sociology or Mobile Studies.

The main theses of the summarized results are as follows:

- mobile communication and physical mobility mutually strengthen each other
- the mobile information society will presumably the society of knowledge instead of being organized around pure information,
- the mobile, interactive, multimedia communication represents a return at a higher level to the original, non-alienated, human forms of communication,
- mobile communication brings about a change in human cognitive capability,
- the nature of political communication is going to change,
- the nature of scientific communication is going to change.

Filter out spinners based on behavior profiles

The purpose of the research is to identify subscribers who use parallel several SIM cards. In the course of the research our main objective was to specify features based on which these subscribers can be identified with high accuracy.
We wanted to find out what are their telephone usage patterns (times, duration, call groups) and what are their demographic features (age group, income).
When treating this subject we utilized results described in the international and national technical literature and obtained from surveys; in addition, the data available on subscribers were also assessed applying data mining tools. The completed study includes the characteristics of the searched subscriber group. With the analysis of the available subscriber data we have created the subscriber profile characteristic of the examined group. The achieved results enable us to get to know more exactly and model the operation of the mobile communications market.

Identification of demographic features based on phone usage patterns

In many instances the subscriber to the service is not the same as the actual owner of the telephone. The purpose of the research is to estimate the demographic features (age group, income) of the person using the service on the basis of its phone usage patterns.
In the course of the research we tried to find out whether the subscriber is identical to the actual owner of the telephone and what are the demographic features of the owner (age group, income). When treating this subject we utilized results described in the international and national technical literature and obtained from own surveys; in addition, the data available on subscribers were also assessed applying data mining tools. The completed study includes the characteristics of the searched subscriber group. With the analysis of the

available subscriber data we have created the subscriber profile characteristic of the examined group. The results assisted us in getting to know more exactly and model the mobile communications market.

Implement quasi natural man-machine voice link in information systems

The gradually expanding services bring about the demand for higher level automation as well; in this respect an obvious tool is the application of speech recognition and speech synthesis.
In the practice the technological novelties were tried out built in voice portals. Based on the WAP sites of wap.t-zones.hu we have worked out a voice news portal, with which the news that can be read on the WAP may be listened to. The voice WAP service was implemented using VXML based voice portal engine. From the WAP sites a server application automatically generates the VXML sites in a dynamic way therefore the user can always access the current news. One can select from the news with speech recognition. The „WAP reader" is more than a new interface to the news sites. This is the only possibility to access WAP sites via phone for those with impaired vision or for customers who do not use WAP.

Acceptance of innovation spreading and technology by consumers

The usual theories (e.g. Rogers) explain the spreading of innovation with social aspiration when the players of the mass market imitate – usually on the basis of the social status – those who accepted in the early phase the innovative products. The primary objective of the research was to survey and analyze variables influencing consumer behavior on the basis of the theoretical knowledge.
In the study where the results of researches performed are described we present the status and segmentation practice of several European markets and enterprises using best practice approach, and deal with the critical issues of innovation spreading on the info-communication market. We illustrate that following the gaining ground of a basic product the further spreading of innovation can be understood not only on the basis of the previous theory, but usage also plays a major role in the process. The typology which takes also into account the use of the product is presented. Since the spreading of innovation is essentially an empirical issue, we have assessed variables influencing consumer behavior which were used in international research projects, where deeper understanding may assist us in seeing more clearly the dynamics and future evolution of the Hungarian market.

Following the discussion of theoretical issues the spreading of innovation will be presented on three international mobile communication markets, referring to the concrete marketing problems and solutions of the companies. In addition, research scales the use of which in future studies on innovation spreading is worth being considered in our opinion were also given in our study.

Principles and practical possibilities of management by objectives at Magyar Telekom Plc.

In the frame of the subject we have examined a group of topical issues relating seemingly to the selection of managerial tools which in reality goes beyond this and concerns the philosophy of management: methodologies applied in management by objectives and Balanced Scorecard.
First the framework of the examination was marked out. We identified the problem, clarified the preconditions then sketched out the issues and methodology of the research. We have interpreted the basic ideas: management, resources, performance as well as – applying both general and concrete approach – the measurement and evaluation. The study compiled as a result of this work draws the conclusions arrived to during the assessment and marks out directions required for further progress. We proposed to shift the general direction of research – following the completion of theoretical analysis – to the solution of practical issues since only empirical research and organizational analysis may give an authentic answer to the following questions:

- how the concepts and systems of performance evaluation are interpreted by the mechanisms and players of the management system;
- what consciously admitted and deliberate or unintended functions and tasks are fulfilled in the organization by the applied procedures;
- where and at which points the necessity to develop the control process is indicated and what are the demands and logic along which this is worth implementing;
- how the network of individual agreements was created and how this is adapted to the levels of links realized within the organization.

Learning responsible corporate behavior

We have performed researches to throw light on the current status of the behavior of Magyar Telekom Group as responsible corporate citizen and to explore possibilities for development in this area. In the frame of these efforts we studied as starting point documents relating to CSR activity, first of all the GRI report. In addition, personal interviews were also made with the concerned managers and employees of the company. One of the first successful application in Hungary of a self assessment method developed in the USA – Self-Assessment and Improvement Process (SAIP) – was an essential part of the research.
As regards the interpretation of responsible behavior the documentation comprising the results of the research gave a wider overview than the current practice of the Group. It analyzed in detail the process of learning responsible behavior at the Group then presented several classification systems developed as a result of independent status identification and qualification methods. In addition, it evaluated the Group, based also on the already mentioned managerial self–assessment (SAIP). The authenticity of assessments was strengthened by the fact that on the one hand several approaches were applied during the work and on the other hand analyses were performed in control groups as well. At the end of the study recommendations and proposals improving the behavior of Magyar Telekom as responsible corporate citizen were formulated in several theses.

Coordination mechanisms in on-line communities

The research performed in the frame of the subject tried to find an answer to the question why members of on-line communities fundamentally help one another. For this purpose forums in Hungarian language connected with technical assistance were analyzed. Two possible explanations of the issue were discussed thoroughly:

- whether compensation is expected in exchange for their actions, or
- the participants intend to establish relations.

We also examined whether more help is given to those offering more assistance if they require it, and whether the non-observance of the non-written rules of the forum is forgiven more easily by the participants in case of more helpful persons.
The result of the investigation shows that the more assistance is not recognized in the form help returned. We succeeded in demonstrating to a limited extent the more forgiving attitude as regards the non-observance of norms. When contacted in the form of questionnaires the majority of participants agreed at least partially with the opinion according to which assistance is reimbursed in these two respects and this view did not change among the more experienced users either. As regards conversation on personal subjects we demonstrated that no increase can be experienced with the time. A considerable part of those attending the forum – but not nearly everybody – used this form to establish new contacts therefore the personal talk via the common interface has not become dominant.

Organizational culture and leadership (management) in the telecommunications sector based on the research of GLOBE

The purpose of the research was to analyze and compare typical cultural and leadership patterns of the telecommunications sector within the existing and future acquisition areas of Magyar Telekom.
As regards the perceived organizational culture the telecommunications sector is positioned between the financial sector and the food industry (being in most instances closer to the values of the financial sector). Three variables are exceptions: in the telecommunications sector the assertiveness is the highest, while the avoidance of uncertainty and the human orientation show the lowest values (the tolerance to uncertainty is the highest here with a significant difference of about 5 %). In respect of expected leadership the values of the telecommunications sector are the lowest as compared to the financial sector and the food industry. One variables is exception: in the telecommunications sector the tolerance to self-centered managers shows a medium value.
The main cultural features of one of the Eastern European countries examined during the research are as follows: large distance in domination (hierarchical structure), strong group collectivism (intensive internal cohesion of smaller communities), strong tolerance to uncertainty (feeling), low power orientation and approach focusing rather on the present instead of the future. Comparing the received values to the world average our relative view on the culture becomes more diversified. Values above the world average can be detected as regards domination distance, group collectivism and gender equality. The values in the domain of avoiding uncertainty, performance orientation, future orientation and institutional collectivism are relatively lower (relative individual approach). The values of assertiveness and human orientation are essentially similar to the world average.
The research enabled us to study empirically the image of successful leadership adapted to the specific Eastern European culture, and to analyze cultural and leadership differences; thus the possibilities and limits of management and know-how transfers can be predicted and the cultural and leadership features of the telecommunications sector may be analyzed in comparison to other sectors.

Removing legal obstacles hindering electronization

The purpose of the research carried out on the subject was to present the modernization elements of public procurement in Hungary connected with electronic support, to explore development opportunities and to map out the expected changes. The compiled study first gives a short overview on the status of electronic public procurement in Europe then deals in detail with the Hungarian conditions. In addition, the electronic public procurement catalogue already available in our country, the framework of implementing the planned electronic auction service as well as the most important elements of the regulations are also briefly outlined.

As a final conclusion we have established what possibilities may arise first of all as regards entering the auction service provider market, and what is the direction T-Com should follow to achieve this goal.

Computer aided learning on networks

The purpose of the research was to create a Hungarian language system for the recognition of proper nouns. Apart from the identification of proper names (nouns) included in the text this system has to classify them in one of the specified groups (in our case forename, place name, organization name and other). The developed system applies the so-called maximum entropy modeling where correlations from which the searched information in the given context can be predicted with adequate accuracy are identified on statistical bases. For automatic decision support glossaries coming from the most various sources have been compiled, assisting our system in a natural way in the identification of proper nouns.

The performance of the system was compared with the published performance values of other systems created for similar purposes and it was established that state-of-the-art result was achieved using the Hungarian data set available for the testing. In connection with the project a guide-book was compiled cooperating with other Hungarian researchers interested in the recognition of proper nouns for the creation of so-called manually labeled corpuses suitable for teaching and assessing systems similar to ours.

Emerging archives: community models for digital preservation, content service and content organization

The majority of products produced by the cultural and media industries (films, television and radio programs, records, computer games, books, comic books) are intended for momentary consumption and these products are no more available after their commercial life cycle comes to an end. According to this practice, even in case of articles not expressly intended for temporary consumption only an insignificant part will be available in shops and via the media channels when two to three years have elapsed since their launch on the market.

In the frame of the research we have surveyed the emerging archiving platforms and initiatives which are currently in operation, and assessed the problems and pitfalls of their functioning, with especial regard to the following areas: creation of interoperability between individual archives, enforcement of copyright constraints, applicability of Creative Commons licenses, development and enforcement of the technological standards of filled in content, organization and systematization of filled in content, applicability of peer-to-peer solutions, making visible of and community filtering for populated contents. Then we made a recommendation on the functionality of on-line community infrastructure used for building emerging archives as efficiently as possible.

Survey the consumer behavior about digital content

The mobile services of the future are determined by the personalized and broadband content and/or infrastructure. In the study prepared in the frame of the research activity we map out the receptiveness of the Hungarian society to new services and analyze how these demands match the current mobile usage and media consumption habits.

In the course of the analysis we have worked out a mobile user typology which may be suitable for the identification of consumer demands and for assisting the design of mobile services. In the study it was demonstrated that as regards the use of mobile phones the complexity of consumer demands and habits depends first of all on the age and on the financial situation. As opposed to the use of Internet the openness to the new generation mobile telephony depends less on the cultural capital that is on the educational level and profession. However, the dominant role of financial aspects (easy circumstances) in using mobile phones indicates that the gaining ground of new services will be hindered by the strong cost limits expressed by the users. We have also proved that among the solvent users the demand for the services depends not only or not mainly on financial factors. There are solvent groups susceptible mainly to broadband audiovisual services, other segments are interested rather in locative mobile services and we can find users attracted by the possibilities of electronic administration and payment. The size, social composition and solvency of these groups may supply essential information for scaling the market of future mobile services.

Processing of Hungarian texts using machine based methods

The purpose of information retrieval systems (i.e. search engines) is to provide from a given collection of documents those which are relevant in terms of a specific – in general textual – information demand. The question may arise, which is the better searching facility:

- the one which retrieves as many as possible documents relevant to the issue from those included in the collection, or
- the one where the number of irrelevant documents among the hits is as few as possible.

The purpose of our research project is to eliminate the deficiency as regards the scantiness of exact measurements performed on a collection of documents in Hungarian to determine the efficiency of the search engines, therefore we do not know precisely how and to what extent the intensive suffixation of the Hungarian language impacts the performance of search engines.

In the course of the work performed we discovered that:

- in case of Hungarian texts the performance of language-independent systems is lagging far behind the English ones,
- a simple rooting algorithm — built on the hunmorph morphological analyzer developed by our research group – improves significantly both accuracy and covering,
- the decomposition of compound words is an indispensable step,
- applying intensive rooting the efficiency of search in English can be approximated for Hungarian as well.

Mobile interfaces of new type

(Research on the prototype of gesture related Mobile Interfaces)

During the research various gestures and mobile usage contexts were measured, assigning to them existing telephone functions; as a result three prototypes were produced. These are functioning but not miniaturized systems where user experience could be tested in its full reality:

- The supersonic telemeter mounted on mobile is useful for applications engaging our attention while moving, since it makes possible to trigger an alarm by phone before potential accidents or collisions, thus enabling both parties to avoid them.
- Using a cube sensitive to movement and tilting we can control some functions of the telephone and we can enter text. With this facility we can differentiate and quickly learn fundamental tasks built on the movement of the device.
- With an accelerometer attached to the phone we have integrated the most widespread communication gestures, decisions expressed by the movement of the hand into the world of mobile sets. To receive the call it is enough to lift the telephone to our ear with an emphatic gesture, while for rejection we only must shake laterally the phone, giving thus a negative answer.

Issues of user archiving: emerging semantics, folksonomy

The objective of the project was to perform comparative test for two types of classification paradigm. First the fundamental ideas of the area had to be clarified, during which particular attention was to be paid to identifying the concept of knowledge organization system as well as the types of such systems.

The first important difference between the two paradigms i.e. between taxonomies and folksonomies (to the benefit of taxonomies) is that in the former ones a hierarchical subordination relation is defined among the elements of the system, giving a well navigable structure to the whole system, while this facility is missing from folksonomies. As regards this feature the latter ones resemble the list of terms. We must take into account, however, the possibility that frequency values are also assigned to the labels of folksonomies. Therefore when defining the concept of folksonomy we must not leave out the sorting relation arising from the sequence of importance – most often frequency – values assigned to the labels. This may give a special (and second) arrangement to the system of labels. On the other hand the value of this second relation is raised by the fact that the frequency values created during community use express the relevance values as seen by the whole (or only a part of the) community, which may provide in many cases excellent searching, orientation and navigation assistance for the users. The explanation for the applicability of folksonomies can presumably be found in this feature.

Digital content production, manufacturing Hungarian digital products in the domain of culture and economies of scale

The purpose of the research was to identify the economic, legal and sociological characteristics while producing, preserving and making available cultural goods in a hybrid media system comprising both traditional (analog) and on-line media. We have examined the impact of emerging on-

line markets on the traditional markets of cultural goods. The achievement of this original objective was attempted with three studies compiled in the frame of the research. In these studies we tried to identify the possibilities opening up before users restricted so far to receptive, passive role after they become as a result of technological changes producers and parts of the distribution system, apart from being consumers. It is also a question what is the chance of these masses of new players for survival, that is how they can avoid that their appearance is a sudden but short-lived event in the long history of cultural markets, how they can play in the long run as well a considerable role in the production, exchange and preservation of cultural goods so that the economic bases of such participation are also created.

Measure information demands and information search

In the frame of the research we tried to identify the information needs of the Hungarian population as well as the sources of information used for the satisfaction of these demands. Based on the data of a questionnaire used for interrogating a representative sample of 1200 persons in June 2006 the study describes the media consumption habits of the population „with Internet capability" aged between 14 and 70 years, including two sub-samples: „the young" (respondents between 14 and 35 years) and „Internet users" (who have Internet connection anywhere: at home, at school, at the workplace or elsewhere). The main aspects were to find out what television channels are watched and what press materials are read by them, and in case of using the Internet what Internet contents they are interested in, and what are the sources from which they obtain information required for solving problems arising in given situations of life (for example renovation of flats, job hunt).

The analysis of the data shows that there is no major difference between the media consumption habits of the three samples, although in the younger age groups the gaining ground of the Internet is considerable to the detriment of the print media. On the other hand the interest of those already using the Internet and the young is not quite the same, thus it may be expected that the demand for the „more sensation hunting" media contents reflecting better the taste of the young will increase on the Internet. Finally we specified special information demands where the media plays a greater role than the community and vice versa.

Analysis of user habits by measuring eyeball movement in case of complex dynamic pictures (multimedia, web sites)

In the frame of the project three tasks have been worked out.

a.) Eyeball movement-pattern test

One of the critical and unsolved issues treated in previous research efforts is to decide whether the automatic and – as far as possible – real time evaluation of large quantity eyeball movement data measured on dynamic web interfaces can be realized.

During the elaboration of the subject the following tasks were performed:

- work out the model of automatic eyeball movement analyzing system based on image processing procedures and algorithms,
- adapt software applications required for the model to the existing and previously used eyeball movement testing equipment,
- implement a first, „demo" version of the processing system.

As far as we know the elaborated procedure and complex system is the first even on a world scale which is able to perform the automatic and – under certain conditions – real-time analysis of eyeball movement data measured on dynamic web interfaces.

b.) Analysis of image databases, retrieval of image information

In the frame of the research task we surveyed the content based processing of image databases, focusing mainly on the aspects of information retrievability. We have taken into account the specific features of images as multidimensional data, the presentation forms of image databases as well as the operational principle of retrieval systems. The closing study describes what the concept of semantical gap means in our case, mentioning several approaches which can be applied more or less to bridge over the interpretation distance between machines and men.

c.) Possibilities of adapting videotheque to IPTV system

In the course of the performed research activities we examined the adaptation to IPTV of a video distribution system developed for Internet and for full functionality browsers. One of the possible applications is the dedicated content sharing among users, which can be realized with two types of technology. The IPTV supports Windows Media 9, Mpeg2 and Mpeg4 formats as well as the digital rights management, thus it is suitable for providing content either free or subject to subscription on different bandwidths.

The main results of the examination were as follows:

- the IPTV is suitable for video sharing only with the application of a web accessory,
- two technical solutions are possible for implementing dedicated content sharing among the users:
  - application of comprehensive Remote Desktop Protocol,
  - creation of individual Video on Demand channels,
- due to the specific features of the interface the IPTV based system requires interfaces comprising few branching and picture elements, where management is possible with navigation using arrow and number buttons and with text input.

Further R&D tasks

Research and development of simple DMT (Digital Mobile Content) management techniques

Mobile operators and carriers having experienced the decreasing average revenue per one customer and the slowing down growth of the number of subscriptions try to find new solutions in the area of content provision with a view to increase the generated revenue. In the frame of the subject we have examined how market opportunities can be utilized.

With the growth of demand for applications, ringing tones, games and useful facilities produced using Java technology the forwarding of these contents to many kinds of sets and to various market areas became a major challenge. The efficient delivery of these new services to users require new investments in infrastructure and commitment on the part of service providers, content providers and telephone set suppliers alike.

The Sun Java Content Delivery Server, the central element of the solution package delivered by Sun to solve this problem makes possible for carriers and mobile operators to promote and assist economical content provision. The Java System Content Delivery Server of full functionality allows the efficient management of content through its whole life cycle, and supports also the handling of digital rights. Support is given for the management of content of many types, including applications, polyphonic ringing tones, images, Symbian based applications, Microsoft SmartPhone and PocketPC applications, audio- and video clips and other service provider specific contents built on wireless Java technology.

Explore and manage the development paradigms and typical solutions of host systems

In the frame of the subject we gave an overview on the wide scale of physical and logical architectures and solutions applied in hosting systems. We dealt with the advantages and disadvantages of server hosting, gave an overall picture on the methods of hosting various services and on the most frequent problems connected with this issue. We have described how the problem of availability and fault tolerance can be solved simply using cluster systems. In connection with the service oriented approach we discussed separately the fundamental questions of data management and data security, and presented three case studies on hosting to demonstrate possibilities for the practical implementation of theoretical considerations.

Monitoring of the operation of industrial objects with mobile tools

Remote measuring and control equipment with automatic operation are applied in the automation system of several industries. In a smaller or larger part of their time these systems operate with local human intervention. Irrespective of the configuration of tele-measurements and remote control system the on-line diagnosing of the status of measuring and control equipment, as well as the possibility to query directly measurements and operating conditions can significantly improve the efficiency of the special service activity fulfilling monitoring tasks and contribute to the economical and reliable operations and maintenance.

The purpose of the project is to work out a remote monitoring pilot application based on mobile technique and a demonstration system functioning in industrial environment. The summary documentation compiled on the subject outlines the selected industrial process and its operation, the alarm system built on SMS implementing mobile thin client based remote monitoring and sketches up the possibilities for further upgrade. The documentation is completed with source programs.

Impacts of the Galileo/Egnos European satellite services

Galileo will be a system comprising 30 satellites and operating on the basis of GPS (Global Positioning System) principle which will begin to operate in 2008. The system will provide significantly greater accuracy than the current positioning services, ensuring also high service reliability. The emergence of Galileo will produce considerable effect on the global mobile market, mainly because the Galileo receiver which can be built into the sets will be available at chip level. The GSM (and UMTS) mobile phones will be presumably among the first ones equipped with Galileo chip. Our examination was focused on preparations for the appearance of Galileo.

According to serious market analyses the combination of mobile communication and reliable positioning opens up still unpredictable opportunities before new, mass applications. In addition to the expressly mobile applications the Galileo applications will presumably generate a huge set of communication requirements, a part of which will be met over the mobile network.

In the completed summary study we described in general the Galileo project, surveyed technologies applied in various, currently available LBS based services, presented and analyzed the already introduced LBS based services and sketched up various market scenarios for the future.

We also identified the possible role of T-Mobile taking into account the different scenarios, worked out aspects for identifying the various business models of LBS based services and made preparations for a pilot application. The Galileo system is a project of the European Union. Its spreading and application in a wide range will intensively be supported by the EU. The already operating EGNOS service assists the preparation, simulating certain features of the future Galileo signals, and making possible already today the testing of prospective Galileo applications on a major part of Europe.

Mobile utilization of RFID technology

This activity covers the continuous monitoring of the evolution of RFID (Radio Frequency Identification) technique, the tracking of utilization methods, and the analysis of changes taking place in the relevant standards that is the follow-up of RFID trends.

The analyses include three major subjects:

- technical overview – analyze the technological, technical and standardization developments of RFID,
- business outlook – follow-up of market tendencies and RFID applications which have become known
- data protection – monitoring of data protection issues and solutions raised by RFID technology.

The result of these tasks is a summing up analysis, describing new developments tools and solutions arising in the area of RFID technology and relating to the given period, with especial regard to their impact on utilization in mobile environment.

Assessment of demand concerning the subject of intelligent home

a.) Supply of wireless sensors and embedded systems

The sensor which detects some characteristic of the environment and forwards it as a digitized signal is a key component for the development of intelligent environment. The launch on the market of devices suitable for wireless signal transmission also gave a new impetus for the gaining ground of sensor systems. This makes possible the development of several new applications and their provision as a service. Such facilities can be for example the supplement of traditional public utility meters, the system controlling public lighting, the measuring of water pressure and a lot of remotely controllable industrial applications. In summary, the sensors allow the application of embedded IT systems in our home and on vehicles as well.

b.) Interconnection of home electronic systems via radio links

A part of household devices are already equipped with embedded control intelligence, but we can talk so far only about individual machines. It is conceivable that in a little while the machines will be connected to some kind of home control center and housekeeping processes will be programmed in advance. For example the heating should change according to the current part of the day but if the Internet weather forecast predicts cold-front then the heating has to be switched on half an hour sooner. The next step would be to integrate the washing machine and the baking device into one process so that when we return home from work washed out clothes, washed up dishes and fresh bread wait us. The various tasks are not to be performed simultaneously, instead the machines involved should report the ready status to one another triggering thus the start of the next work process. By doing so the load of the energy network also can be made more even.

The project deals with the possible technologies needed for creating an intelligent home center, describes the expected costs of implementation and outlines international examples, developments and development trends.

Modeling the development of a service catalogue

The implementation of the project was planned in two phases. In the first phase we reviewed in principle, systematized and assessed the existing methodologies, standards and the system of available devices. In the second phase we created based on our knowledge about methodology a model which is capable of handling service dependency, failures and incidents as well as indicating changes or modifications relating to the services.

The first phase terminated on December 31, 2006 touched upon the following issues:

- How a service can be described?
- What kind of hierarchy can be developed among the groups?
- What particular relations may be defined between the services?
- What is/are the process/process steps along which the cataloguing and the updating of the catalogue can be performed the most efficiently?
- What functional units or roles are affected by cataloguing?
- What is the expedient approach for sharing the steps of the cataloguing process among particular roles and functional units?

Comparison of ATCA platforms, trends, future, interoperability

In the segment of the market engaged in the manufacturing of telecommunications infrastructure substantial investments are required for making an entity a major player on the telecommunications market. The industry felt the need for radical changes since the steadily growing expenses foreshadowed a nightmare of frozen evolution. With a view to assist the opening of the market a telecommunications industry standard called Advanced Telecom Computing Architecture (ATCA) was worked out creating the bases for a modular architecture built on open standards and used for running „carrier grade" telecom applications. This is one of the essential elements needed for reforming the market dealing with telecommunications infrastructure. The purpose of our research task is to review from the aspect of manufacturers and operators the impacts of ATCA technology on the telecommunications infrastructure business branch.
In the closing study prepared in the frame of the subject we first describe the ATCA standard then analyze its impacts on the cost structure of the business line and on the market entry threshold. We also presented the new situation arising due to the shifting of the market entry threshold as well as the modified strategy of suppliers and operators under the new conditions.

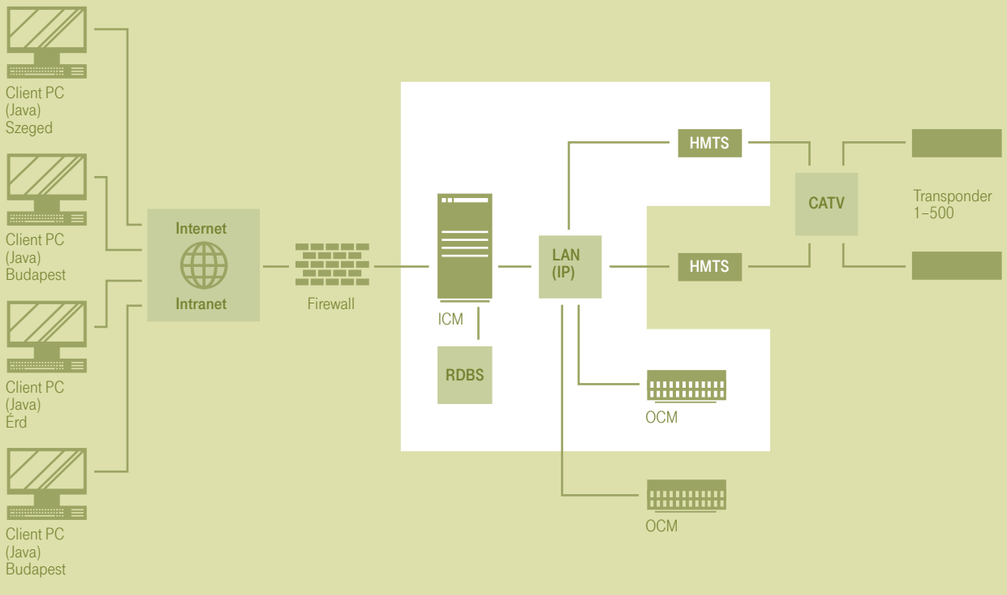
Development of electronic segmentation device

The study completed in the frame of the subject gives an overview on the evolution of cable television network characteristics and topologies, on hard-to-solve tasks encountered at particular development levels, then deals with the development of efficient network segmentation equipment which support the physical and logical architecture of today's up-to-date networks showing the way towards the digital future. The authors discuss the conceptual and practical issues of system configuration, the steps needed for implementation, then make a proposal on the use of headend equipment suitable for handling forward and backward CATV network segments which can be integrated into a unified remote monitoring system and can be remotely managed.
The material examines the actual tasks on the basis of concrete examples. The conditions of integration into the remote monitoring system, the hardware and software features of the applied system control elements and the method of programming them are also touched upon.
Using a practical example the study describes the installation steps of devices required for the re-configuration of a currently operating headend facility indicating also the actual, concrete tasks to be performed and outlining advantages to be experienced during the expected later upgrades and transformations.

Management solutions for coaxial cable television networks

The work was performed with the purpose of making preparations for the practical implementation of T-Kábel concepts on the development of Network Operations (Management) Center (NOC). In the frame of the task the previous Budapest pilot system had to be extended to the South Eastern region of Hungary and the possibility for implementing the central monitoring of VoCa and Vnet services had to be analyzed.
The authors of the completed study make detailed efforts to find concrete, practical solutions to increase the operations level of cable television networks, to improve the availability of emerging new services, and to reveal network faults applying a preventive approach.
The architecture of the monitoring system is shown on the previous page.

The architecture of the monitoring system



Assess the possibility for the introduction of value added, digital TV services

The digital cable television service of T-Kábel was launched in December 2005. In the last year the system was expanded to a 77-channel one with the digitization of the analog channels; further upgrade is conceivable by the introduction of value added services.
The study gives a detailed overview on supplementary services which can be offered on digital television infrastructure, describing also the possibilities for their technical implementation, and surveys foreign references on the introduction of individual services. The material outlines possibilities for the development of IPTV service on cable television network as well.
As part of the task an NVoD test system allowing the assessment of services in the practice has been implemented under laboratory conditions. The test results significantly contribute to the business introduction of the service.

Technical and economic analysis of new information transfer technologies

The purpose of the task was to work out new program providing and technology alternatives which enable the Service Provider to consider existing and potential solution possibilities for the satisfaction of demands arisen and to select the most appropriate system, offering thereby the optimum solution to customers. When analyzing demands possibilities suitable for the supply of quite small communities and areas are also to be taken into account.
The material describes three different technical solutions.
The EttH (Ethernet to the Home) improves the competitiveness of Multi-Service Operators (MSO) in both the residential and business segments where with the emergence of xDSL and „penetrating fiber" applications (for example Fiber To The Home: FTTH) the competition becomes stronger and stronger. As opposed to the currently applied cable based data access solutions the EttH offers considerable technical, operational and business advantages.
The CaTV solution also was created based on the convergence of various technologies and offers a feasible approach in an environment where due to the specific features of the building the telephone, Internet and cable television services can be transmitted only via Ethernet network.
The material gives an overview on the possibilities of applying wireless therefore radio frequency transmission by subscribers making use of multimedia services. The knowledge and practical application of new information technologies make possible for us to offer the most cost-effective technical solution in the future for the satisfaction of various market demands.

IP based transmission of DVB-C signals in practice

The study prepared in the frame of the subject deals in detail with the implementation possibilities of transmitting DVB-C signals over the IP network, describes the characteristics of the measuring tool which may be applied for the control of IP signal transmission as well as the mode of application recommended during the control.
The developed measuring procedure allows the user to identify and make continuously available via the IP network the qualitative characteristics and stability of DVB-C signals transmitted between the defined interface points over the IP network. The practical application of the software significantly improves the efficiency of operations and allows us to deliver in the future the DVB-C service to other, regionally separate cable television networks as well.

Optimum development of the Ethernet backbone network of Emitel Zrt. taking into account traffic routing and operational security aspects

A homogeneous Ethernet network comprising devices supplied by one manufacturer provides the backbone network background of ADSL Internet service offered by Emitel Zrt. The continuous growing of the traffic (taking into consideration the IPTV service as well) makes necessary the optimization of the network. The purpose of the project was to supply guidelines for the further expansion and refashioning of the network.
The study compiled in the frame of the project modeled the network of Emitel and prognosticated the growth of traffic on graph theory bases. A proposal for the smaller or larger transformation of the network was made at both optical and Ethernet level. The proposals affect the following areas:

- reasonable sequence of increasing the speed of sections,
- alternative possibilities for network control,
- construction of new optical path,
- optimum locations for the application of WDM.

Following the presentation of various measuring methods the authors of the study worked out a proposal for building an appropriate traffic monitoring system as well. The reliability analysis examined the following issues in case of the existing and recommended network topology:

- availability of the links based on the reliability parameters of active devices and network sections,
- blocking probability of links.

As a final conclusion of the performed analysis we can establish that following minor topological modifications the Ethernet backbone network of Emitel will be suitable for carrying the multiple of current data traffic at adequate quality level.

Development of models supporting efficient customer management

The purpose of the project is to create and/or upgrade models suitable for the further analysis of calling community clusters between subscribers and for indicating in advance churn due to traffic and fee arrears reasons – in addition to the forecast of churn requested by the subscriber. The created models fulfill the functions detailed below:

- Hidden Markov state descriptions (model for the forecast of traffic churn – alternative labels /tags/): Monitoring the changing in time of traffic service utilization the model creates usage groups and behavior transitions, then generates exposure groups from them.
- Classificator forecasting arrears with payment: In addition to the methods applied for classic churn (decision tree, SVM) we have developed the linear regression classificator which gives good results in case of churn. Using this tool we are able to generate every month in the data warehouse of Emitel Zrt. the list of customers having become seriously exposed to churn due to arrears with the payment of fees.
- Upgrading of the visualization interface of the Community Explorer used for display the calling community: in this case two key elements were analyzed:
- In the cluster outputs generated every month the cores of the calling community are also marked already (not only by color) and they can be separated on the interface as well. The selection of cores is possible according to several definitions to be elaborated.
- The filtering attributes can be interconnected with any logic relation therefore we can already develop a logic formula where the various conditions may be concatenated using „and", „or" and „not" operators.
- New method of grouping based on relationship network: In case of the Community Explorer program the preliminary measurements proved that the quality of calling communities produced by the current OPTICS algorithm can be improved with the application of other algorithms. As an alternative approach, iterative partitioning clustering based on the Bayes method was developed. The calling network between residential subscribers was constructed on the basis of the detailed call log generated monthly. This is followed by a multi-level classification process during which the already identified classes are further divided hierarchically into smaller classes at each level, thereby the subscribers are organized into a tree structure.

Analysis of IPTV services

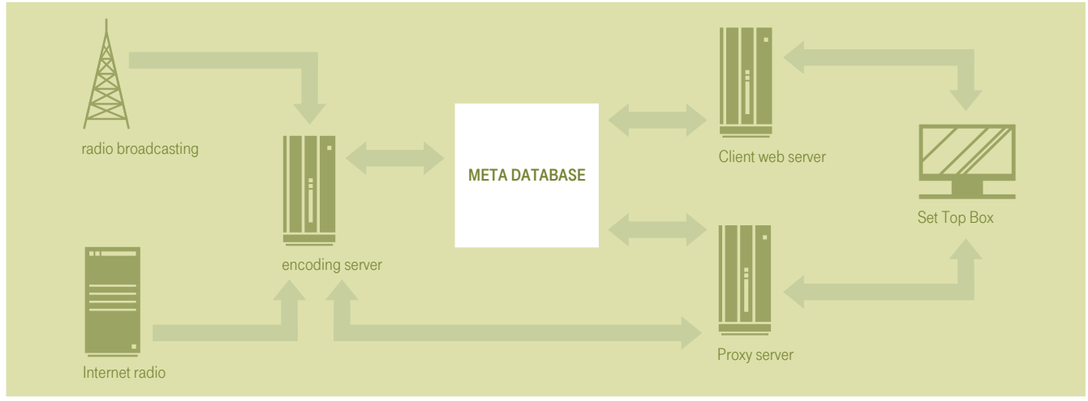
In the first phase of the research activity a pilot IPTV system was built out. In the following this facility was used to analyze from the aspect of IT support possibilities the content management working process of IPTV live media flow transmission and on demand services. The analysis of the working process covered also the issues relating to the connection of content source partners. The completed analysis explores the potentials of logging and reporting process used for content management. In the further part of the research we examined the possibility of using Internet applications (browser, mailing, game, etc.) which can be realized in the software developer environment of the user platform and implemented for experimental purposes a browser application to the developed technical solution.

Integration of radio content into IPTV platform

The purpose of the research was to analyze how the IPTV system can be made suitable for the transmission of a linear radio signal flow and to design a configuration where the tests can be carried out. In the course of implementation a transmission in analog or digital format is taken over from the program provider. For this purpose a meta database has to be created and an encoder has to be selected and adjusted to the incoming flow. In connection with the transmission flow to be delivered to the client the monitoring of the client is necessary; this is implemented on the administration interface created for this purpose. As a final step a client which can be used on the TV interface as well has to be established either with the built-in functions of the system or applying a solution developed by own resources. The system is illustrated on the top of the next page.

Web operating system

In general the operating system is a software enabling us to store, edit and delete our files simply, via an easy-to-use interface. However, the major strength of the web operating system is that the files are stored on a server and they can be accessed or modified from anywhere, using a graphic browser running on a computer provided with Internet connection, and we do not need to install for this purpose plug-in units or software products.



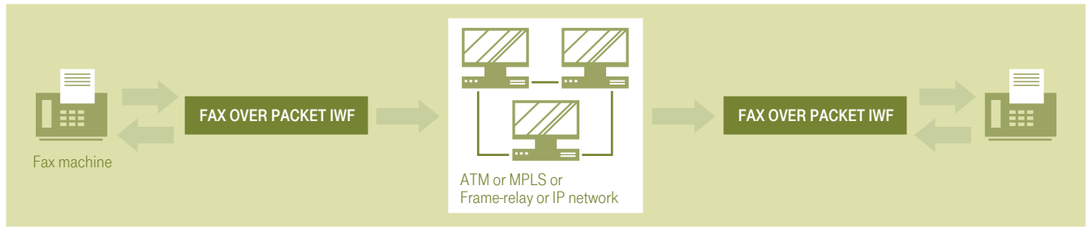
Our purpose was to create a system which enables us to access without difficulties and considerable skill in IT issues the usual user interface of computers applied all over the world and interconnected via the Internet, to reach our own documents and programs, to establish contact with acquaintances and to share files without the need for installing anything or buying expensive commercial software products. The Boss Os was designed so that the system runs on the Microsoft Windows operating system the same way as when applying Unix, Linux or Mac. In addition, we also wanted to find out why similar systems available on the web (youOs, eyeOs) did not succeed in attracting their own extensive user groups.

Facsimile, DTMF and modem transmission issues, solution possibilities and measuring methods in IP based networks

The quality requirements of supplementary services provided on the traditional telephone network (for example fax transmission) are quite different from those of IP based voice transmission. For this reason these services either do not operate in case of VoIP systems, or their functioning is not guaranteed.
According to the findings of the study compiled on the subject the operational deficiencies may be eliminated but the possible solutions are still in the experimental phase or are being standardized therefore are not included yet in the products of manufacturers. The study outlines the possible solutions and the two most promising ones are analyzed in detail as well. In addition, the research trends connected with the subject are also surveyed. The following figure shows the possible solutions of fax transmission on VOIP network.

IP VPN interconnection possibilities, with especial regard to the quality requirements of IP based voice transmission.

The administration of a network developed by making use of VPN technology is much easier than that of an own, physical network. Should changes occur in the topology, the administrator can spare the trouble of cabling (or performing any other task in the physical layer) since the maintenance of the physical network is the responsibility of the service provider. Topological changes can be implemented in the logical network with reconfiguration. Thus the expansion of the network is much easier than in case of physical network; the service provider also can grant access to a new site of the customers with the modification of the configuration.
It is, however, a fundamental problem how service of guaranteed quality can be provided on the IP network. The study prepared in the frame of the subject deals with a special case of this problem, when there is MPLS below the IP layer and IP VPNs are created for the customers in the service provider network. The study describes third layer VPN services which can be made available in the MPLS network then – managing these facilities as network – outlines feasible solutions within network and between networks, focusing on the possibilities of providing services of guaranteed quality in such cases. The quality requirements of IP based voice transmission is a key issue discussed in the study.



R&D consortiums

The strengthening of innovation is one of the objectives laid down in the corporate strategy. For this purpose – apart from the involvement of external resources based on bilateral agreement – we joined also together with our external R&D partners (ELTE, BME) research-development projects financed by the state where the results may be directly utilized in our development tasks in short- and medium term, enabling us to include external research resources in the elaboration of tasks impacting Telekom as well. In the following we present the results of such research projects performed in the frame of consortiums and describe how the results can be utilized within Magyar Telekom.

Adaptive media flow service architecture for the latest mobile telecommunications systems

The project includes basic research, applied research and experimental development tasks built one upon the other. The purpose of the project is to develop a media flow service architecture suitable for providing quality media flow (streaming audio and video) services and applications to the subscribers, in a scalable way and flexibly adapted to user demands and to the changes of network status in mobile and fixed-mobile convergent environment.
In the second reporting period of the project (2006) the most important objective was to close the applied research tasks with results which either can be used in themselves as useful achievements in the practice or may be presented under laboratory conditions and integrated into the pilot system during the third, final working stage. During this period the following partial tasks were worked out in the frame of the project:

Applied research tasks:

- media flow transfer in heterogeneous access networks,
- provision of service quality,
- dynamic client-server capability harmonization,
- data- and service security issues,
- virtual overlay network.

Experimental development:

- development of an experimental test environment.

A few from the obtained results must be emphasized.
The experience gained in connection with the vertical handover implemented in the test system may directly be utilized for the development of DualPhone service. The video flow optimization solution can be applied for the development of streaming service, and may be the basis for the improvement of its quality. The results of the study discussing security issues and media encoding solutions can be utilized in technical specifications and tender invitations. The completed network optimization and simulation software enabled us to gain useful experience for the development of the 3Play service streaming network.
To integrate the results of some applied research tasks, to develop interoperation between partial solutions and to create the unified demonstration system are tasks to be performed in 2007.

Mobile 2004

During the planning of networks we need – among others – algorithms which are suitable for identifying the traffic of individual relations that is the current traffic matrix of the network from the measurable traffic data of the network, in the knowledge of the network topology. To study procedures operating according to different principles and to compare these procedures in terms of the accuracy, convergence, rapidity and data requirement of results were parts of the research efforts. The methods developed in the frame of the research task can be utilized in the course of IP/NGN network planning and network resource calculation works.
When analyzing the feasibility of services based on fixed-mobile convergence we dealt with the elaboration of solutions which make possible the provision of converged services, the management of the network and the integration of the IMS (IP Multimedia Subsystem) in heterogeneous network environment. We were the first to work out a mobile VPN solution providing permanent network access in heterogeneous network environment for programs running on client mobile devices. We have also analyzed the client side implementation of this solution and its scalability on the server side. Finally we dealt with the handling of SIP links in the IMS system: the expansion of established SIP links with other media transmission, the SIP-SS7 signaling system conversion and the application possibilities of the PARLAY principle. The methods developed so can be utilized during the DualPhone and IMS developments.
In the course of research efforts we have examined the possibility for extending multimedia services using multicast technique as well to the mobile access network. We have studied the multicast and QoS capabilities of MBMS (Multimedia Broadcast/Multicast Service) and WLAN technologies as well as their possibilities for upgrade. In the course of implementation we participated in assessing adaptability to existing services, to the network infrastructure and to protocols. The main utilization of research results may be to implement the extension of IP based media services (for example IPTV) in wireless access networks. In addition, we can use them when compiling the system of requirements obtained from various tools.

Due to the professional coordination of subprojects we performed – among others - measurements concerning the quality of link which may be provided for premium VoIP services and/or we tested several network tools; as regards the results, they can be utilized during DualPhone, KLIP and IPTV developments. In addition, preparations for a Hot-Zone demonstration are underway, in the frame of which we set as target the provision of QoS at the Hot Spots.
To assess the multicast possibilities of networks where the devices do not support directly the multicast represents a new research area. In the course of the works we have examined how a fixed IP network with multicast capability can be connected in a transparent way to network parts where multicast is not supported. The research assists us to identify how for example the IPTV service or in general multicast based video signal may be transferred and extended to a - not only own – IP network service point.

Optimization of video information transfer in wireline and wireless info-communication networks

The purpose of the research is to find solutions to high level quality assurance, efficient operation and rapid fault clearance of IPTV service launched at the end of 2006.
The IP networks were not planned originally for television broadcasting therefore error-free, quality and real time video transmission can be implemented only with careful technical design. The IP network designed primarily for data communication has the following video specific features and conditions:

- the overall delay of data transmission has to be minimum,
- the fluctuation of packet transfer delay may not exceed the maximum jitter time which can still be managed by the decoder,
- any loss of useful packet without repair results in picture distortion or service failure,
- due to the real time feature the repair packets may follow the originally planned reception of the erroneous packet only with a small delay,
- even if the most up-to-date encoding procedures are applied, the video bandwidth is considerable (2.5 Mbit/s on the average assuming H.264 video encoding).

The conditions show that all the natural features of packet based data processing are disadvantages from the aspect of video transmission. Nevertheless it is expedient to adequately control these parameter values since the Internet slowly becomes available in every household therefore the most fundamental home entertainment service can be provided without the installation of traditional TV distribution networks. The availability ratio of IPTV service can be calculated by multiplying the availability indicators of the various transmission network sections. The quality and stability of the service are determined by the least stable elements of the transmission network. The purpose of the research was to identify conditions and measuring technology which enable Magyar Telekom to provide the best possible quality IPTV service on the company's IP network.
The quality degrading effects appear at various points of the network therefore end-to-end monitoring procedures are required for measuring the quality as perceived by the user and for making possible the traceability of error sources. In the first phase of the work we reviewed the transfer points which are essential from the aspect of IP network monitoring: starting from the schematic system technology and using the practical experience gained so far we tried to reveal the sources of video transmission faults. In the frame of information gathering we looked for measuring devices and measuring instruments which are at least in the market introduction phase. The research results supplied the basis for the development of the 3play monitoring system being currently procured.

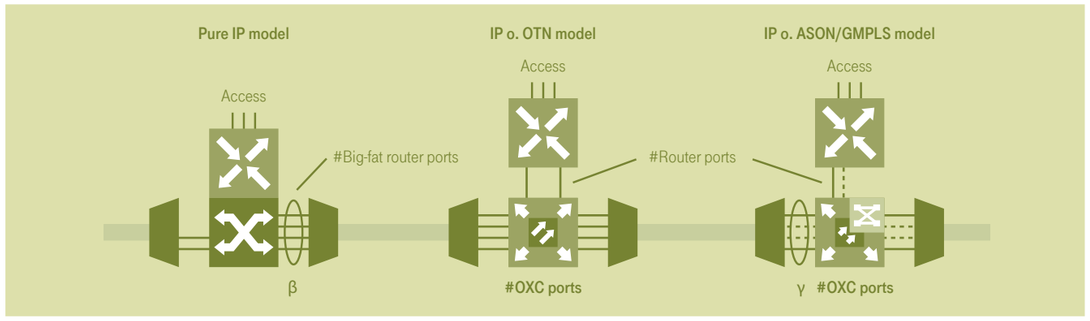
Assessment of the quality of IP telephony, video telephone and video applications in function of the measurable network parameters

In the frame of cooperation realized within the NAP consortium we launched a joint research and development project together with Collegium Budapest Association for the performance analysis of applications transmitted over IP. The purpose of the common research planned for several years was to assess in function of the measurable network characteristics the quality of various voice and video applications implemented over the IP. As the first step of the work, our goal for 2006 was to analyze various voice transmission applications implemented over IP, but in addition to describing the quality features of voice transfer we tested the picture transmission quality of some video telephone applications as well.
For the performance of the measurements first a laboratory network configuration modeling the performance of the real network was set up. In this simulation environment the performance indicators of the modeled real network could be set and modified according to demand so it was possible to assess the quality of applications without using the real, operating network for the tests.
In the laboratory network system we worked out new algorithms for the control of packets, enabling us to set the delay, fluctuation of delay or packet loss parameters of packets in the tested applications either randomly or according to a given distribution function. When rating the

applications we examined first of all the impact caused by the changing of these characteristics but the tests performed covered the transmission rate of connections, the load of links, the hop number and the subscriber access rate as well.
In the course of the work we analyzed correlations between network level and application level performance characteristics and examined what approximative or exact mathematical functions can be given to describe these interrelations. The results of MOS (Mean Opinion Score) assessments were presented on graphs and the analytical approximative functions applicable in the course of network planning were adapted to the curves according to the principle of minimum squares.
The research results achieved in the frame of cooperation among members of the consortium may directly be utilized in the design and cost-effective development of IP networks created for the implementation of business cases. The results of this work are particularly useful during the introduction phase of 3Play service when we have still relatively few practical experience about voice and video services implemented over the IP.

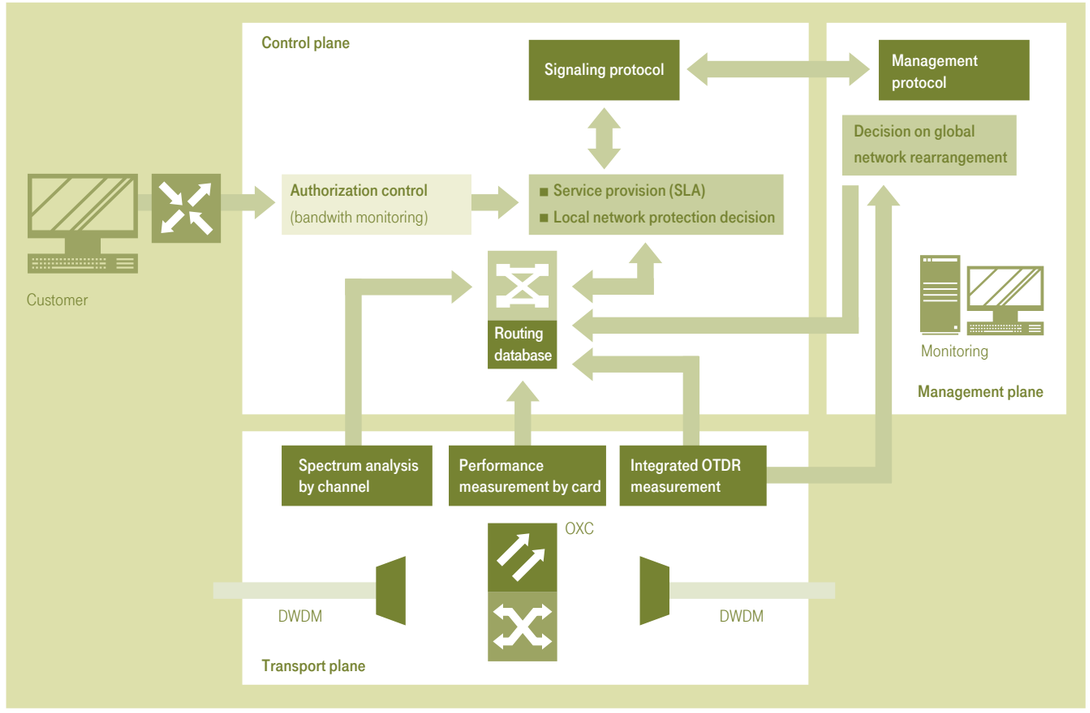
Detailed elaboration of the reference architecture of intelligent optical backbone network in the frame of the MUPBED project

The PKI Telecommunications Development Directorate of Magyar Telekom takes part in the MUPBED (Multi-Partner European Test Beds for Research Networking) project supported by the European Union. The three-year MUPBED project was launched in July 2004 with a budget of EUR 9.5 million; the contribution of the European Community to the project budget amounted to EUR 5.3 million.
The main purpose of the MUPBED project is to analyze and describe advanced network technologies and solutions which help to build the ultra broadband research networks of the future and fundamentally ensure the competitiveness of European research networks. In order to achieve this goal the MUPBED lays particular emphasis on analyzing the requirements of emerging multimedia applications and interoperating systems – such as the GRIDs – and works out the appropriate network architecture taking into account the latest technological developments. The key to this activity is the introduction of ASON/GMPLS (Automatically Switched Optical Networks/Generalized Multi-Protocol Label Switching) based control plane in the environment of research networks comprising usually several domains. With their distributed control functions the above-mentioned technologies make possible the flexible and dynamic configuration of optical links in the network.
In addition, the MUPBED dealt with the issues of optimum interoperation between broadband applications and dynamic communication networks and with the relevant innovative solutions.
The activities of the MUPBED project are performed in five Work Packages (see HYPERLINK "http://www.ist-mupbed.org" www.ist-mupbed.org). PKI contributes to the efforts of Work Package 1 (WP1) which is responsible for the specification and continuous fine tuning of the reference architecture of the test network developed in the course of the project.
During the performance of tasks scheduled for 2006 Chapter 4 (Definition of basic scenarios for simulations) of the document entitled „Preliminary analysis of the results of the project experimental activities" considered as Deliverable 1.3 was fully completed. The simulation analyses of Chapter 5 (Simulation results and analysis) were carried out by PKI in cooperation with the University of Milan. The network models are illustrated in the figure below.
After defining the simplified models of fundamental network architectures the main objective was to analyze the CAPEX and OPEX aspects of the models. Using the analysis methods proposed by PKI the cost components of the architectures became comparable with the assumption of simple traffic statistics. In the light of MUPBED network topology and traffic forecasts the created models were backed up with simulation results as well for the validation of the recommended analytical models.



Services over up-to-date optical networks, fulfillment of GVOP tender in 2006

The GVOP 3.1.1 or in short the KEOPSZ project (see http://opti.tmit.bme.hu/projects/keopsz/) was launched in 2005 with the participation of Alcatel Hungary, the TMIT Institute of BME and Magyar Telekom as members of the consortium. The project is closely harmonized with the PROMISE (Provisioning and Monitoring of Optical Services) project of the CELTIC European research program (see HYPERLINK "http://www.celtic-initiative.org" www.celtic-initiative.org) which means the common utilization of results.
The 2-year project analyzes from service centered aspect the up-to-date optical networks with the primary purpose of showing the way from the current transport architectures towards the fully optical, service controlled and intelligent optical networks. The targets include the support of advanced services with high capacity requirement with end-to-end quality guarantees and reliability. The project covers several areas of the optical networks such as switching, control and management, reliability, network operations, service quality guarantees and end user applications.
In the first year of the project (2005) the arising optical services were defined and the major requirements to be met by systems providing new generation services were specified with the participation of Magyar Telekom. In 2006 the most important tasks were to specify the conditions needed for the introduction of optical services and to define the management, control and monitoring functions required for such services.
With the fulfillment of the partial task „Conditions needed for the introduction of optical services" the examined new services have been integrated into the existing infrastructure and the service platform implementation possibilities as well as the migration strategies have been explored. The performance and cost-effectiveness issues were dealt with in the frame of detailed SWOT analysis.
The documentation of the partial task entitled „Specification of measuring and monitoring solutions" details the parameters which can be measured in the network, sums up the possible measuring techniques of these parameters, and points out the useful application of the measured parameters in the area of service quality assurance, traffic routing and during the development of protection. We also examined what parameters are worth being measured and at which part of the network for drawing general conclusions from the obtained data. The result at system technology level is shown in the following figure.



Exploitation of R&D results

As output of R&D activity pursued at Magyar Telekom there are one hand the technical prototypes of future market products and services developed, on the other hand, the substantial further development of already introduced products is taking place. Related to this activity, for supporting procurement we elaborate the technical specifications of tender invitations and carry out the Magyar Telekom compliance testing for the devices considered. Following these tests we issue Expert's Opinion documents on them. To support network development and O&M activities, we perform comprehensive tests with devices waiting for introduction or with those, already operating in our network. Thus our professional knowledge obtained with R&D is actively and efficiently utilised in the resolving of technical difficulties we eventually encounter in our daily business operations.
Bringing products to market within the possible shortest time - today this is the most challenging task for the providers. Therefore, it is inevitably important to get aware of the pros and cons, the advantages and disadvantages, or limitations of emerging new technologies. Development of technical prototypes helps marketing organisations a lot in the designing of future products. The technical organisations of Magyar Telekom have participated in the development of 62 products during 2006. R&D activities provided a basis for the introduction in the last year of WiMax based, EasyNet, VoCaTV, Klip and IVD products.
All equipment applied in the network is purchased by Magyar Telekom in the frame of tendering, while striving for financial and technical optimum. Elaboration of tender technical specifications and technical evaluation of submitted tender bid documentation is a task of primary importance for successful tendering. The assessment procedure is often accompanied by the functional testing of materials, devices and systems being the subjects of the procurement. The stock of professional knowledge gained with R&D is inevitable for the execution of these tasks. In 2006 we have elaborated 21 technical specifications (requirements) for the important technical development projects of the Company.
Practical introduction of the purchased devices cannot be performed without provisioning-related technological guidelines or specifications. In 2006 in this field an outstanding task was to elaborate - altogether 13 - such technological directives for broadbanding, for multimedia developments and for the introduction of development results of high-speed multi-wavelength optical systems.
Magyar Telekom compliance test means a conformity assessment and classification testing procedure carried out on active (e.g. fixed, wireless, optical, data transmission, modem, router, switching, HUB, power supply, air-conditioning, etc.), or passive (e.g. cabinets, boxes, distribution frames, optical and electrical connectors, cables, etc.) components and telecommunication management/supervisory systems, with the purpose of testing and controlling of the compliance of such components and systems with the network requirements of Magyar Telekom. Within this scope - among others - we have tested the ADSL Ethernet DSLAM-s and the CPE units interworking with the previous ones. We were actively involved in the selection and qualification of Home Gateway, Set Top Box and digital head end station equipment necessary for the introduction of IPTV service. We have prepared the technical specifications for the selection of the devices needed for our VDSL2 and GPON pilots and have investigated whether the devices of which vendors could meet our requirements. During 2006 we carried out qualification testing altogether of 330 devices.
Utilising the knowledge acquired in the course of the elaboration of development tasks, we can considerably support O&M activities, too. On the laboratory networks established in our Centralised Technical Support Centre we can reproduce errors, faults and judge the operability of the corrective patches without disturbing the operation of the "living" services. Thus we can carry out technical tests necessary in the course of introducing new services. Besides supporting the activities in connection with handling of telecommunication software, their updating or upgrading according to need, or testing and elimination of rarely occurring special error phenomena, we can contribute to the enhancement of the reliability of the telecommunication network also by performing tests demanding special professional skills.

Domestic and international R&D co-operations and relations

Our system of relations maintained for decades and our co-operations renewing in the recent years with our partners, are the most important sources for Magyar Telekom to obtain knowledge. These relations with our domestic and international partners are wide spreading, nevertheless they can be categorized into three major forms of co-operation: keeping relations with the institutions of higher education, co-operation with standardization organizations and project-like co-operations aiming at the gaining international experience and exploitation of possible synergies.

In the recent years we have laid much stress upon the international co-operations carried through within Deutsche Telekom Group with the purpose of exploiting group level synergies, focusing within that on the adaptation of development results to the Hungarian market, the sharing of experiences gained with the introduction of products, on the co-ordination of vendor relations and procurement activity, if it is relevant from business points of view. Further on, we maintain close relations with our strategic partners, enabling the harmonisation of technological roadmaps, the mutual involvement of each other already in the development phase and getting knowledge about market experiences obtained on other markets.

Domestic co-operations

Educational institutions

Magyar Telekom has been maintaining - traditionally for decades - close relations with the institutions of the Hungarian higher education system, such as with the Budapest University of Technology and Economics (BME), the Kandó Kálmán Faculty of Electrical Engineering and the Neumann János Faculty of Informatics of Budapest Polytechnic (BMF) and the Budapest Corvinus University. From the universities located in the countryside, we give diploma themes to the graduating students of Pázmány Péter Catholic University, the Janus Pannonius University of Pécs, the University of Miskolc. These students while working on their theses are actively involved in the practical development activities pursued at PKI. In the frame of these mutually beneficial co-operations we can ensure that in the research and educational thematics the contents requirements of the competitive sphere are incorporated with growing emphasis.

Training and Knowledge Management Directorate (KTI) is not only managing on company group level the relevant knowledge management and training activities but takes part in the elaboration and execution of various research programs, too. Accessing to and maintaining contacts with the media and communication researchers and research centres operating in Central and Eastern Europe are important elements for the execution of its functions. The appropriate assistance and scientific background for this broad international network of relations are provided by

CEU and the Media Training and Research Centre (MOKK) of BME.
The Media Training and Research Centre (MOKK) was founded in 2002 as a common project of BME and Magyar Telekom and since that time it has become one of the most successful examples in Hungary of co-operation of the role players of the university and the industrial sectors. From the very beginnings the Centre is the meeting point of university and theoretical research and innovative development projects addressing practical problems and sharing experience coming from the industries.
In the Hungarian higher education system MOKK is a determinant institution focusing on the research of the social affects of internet technologies and their new ways of (community) applications and a key partner of projects dealing with digital archives and linguistic issues.
Since its foundation Central European University (CEU) has the mission to be one of the outstanding research and knowledge centres of the region. The Centre for Media and Communication Studies (CMCS) which was founded in 2003, has achieved even at European level outstanding research results. The most important outcome of the co-operation of CEU and Magyar Telekom that there has been implemented an international academic research network, resting on such pillars as the Annenberg School for Communication at the University of Pennsylvania, the Oxford University, the Stanhope Centre London and the Cardozo Law School. CMCS has made possible the establishment of a "Media, Information and Telecommunications Policy" stream, too, which is a unique initiative in Europe. The aim of it is to better understand the media and communication processes and their new phenomena, from a wider perspective engaging relevant academic disciplines, like political science, law, sociology and others.

Scientific organisations

Traditionally, we have the oldest professional relations with the Scientific Association for Infocommunications Hungary (HTE). We have two PKI representatives in the Board of the Association and we take part in the work of almost all sections. We represent the standpoints of Magyar Telekom in the organising committees of various events and contribute to the work with our relations.
Magyar Telekom has been member of the Hungarian Association for Innovation (MISZ) since 1996. From 1997 on the Company has been regularly taking part in the National Innovation Award Competition and till today has been awarded three times with Special Innovation Award for its four submitted competition papers. To the 15th National Innovation Award Competition (2006) we have submitted two papers. One of them was submitted as a joint competition paper of T-Com and T-Online, under the title "T-Home TV - IP-based television via DSL access"; the other one came from T-Mobile, and had the title "Up-to-date cooling of stations of communication networks". The judgement committee has qualified both as significant innovations, and awarded the latter with a certificate of merit. The successful participation demonstrates that Magyar Telekom from year to year appears with remarkable innovation results.

International relations

Standardisation organisations

European Telecommunications Standards Institute (ETSI) is one of the official standardisation bodies of the European Union. Magyar Telekom has a full membership in it for years. The ETSI standards and specifications form the basis of the international interworking of telecommunications networks. Magyar Telekom has been regularly participating in the meetings of the professional committee ETSI TISPAN (Telecommunications and Internet converged Services and Protocols for Advanced Networking). In 2006 the priority one task of ETSI TISPAN was to complete the first release of the IMS based NGN architecture and start the work on the second release. The NASS (Network Attachment Subsystem) and RACS (Resource and Admission Control Subsystem) the NGN's authentication, end-to-end quality service provisioning and transport controller subsystems were in the focus. The seventh release of 3GPP IMS and the first release of TISPAN IMS include already a number of harmonised functions, and the convergence of these two specifications is a long-term goal. Within TISPAN Magyar Telekom is participating in the activity of Work Group No. 2 (Architecture) and Work Group No. 4 (Numbering Addressing and Routing).
The standards elaborated by ITU-T and ITU-R branches of International Telecommunications Union (ITU) ensure the world-wide compatibility of telecommunications networks and services. Similarly to ETSI, the working papers of ITU serve as important input information in strategic issues.
One expert of PKI participated in the work of Study Group (SG) No. 11, which is dealing with the elaboration of the recommendations for NGN network signals and protocols and the technology of access networks.
Standardisation of DSL technologies is an issue addressed both by the TM6 Work Group of ETSI and by the SG 15 of ITU. Our participation in these activities helps us to utilise the latest experience in the preparation for the introduction of higher speed subscriber connections, i.e. for the installation of ADSL2, ADSL2+, VDSL, VDSL2, HDSL and SHDSL systems.
Magyar Telekom Group has been a member of The European Telecommunications Network Operators' Association (ETNO), and thus may take part in the activity of the Association's work groups with full consultancy power. The R&D membership serves on one hand the goal of getting insight into the development endeavours and projects of other European telecom providers with the purpose of exploiting and identifying the possible fields of co-operation. On the other hand, the harmonisation of developments launched or to be launched in the framework of the research and development programs of the EU (6th Framework Program and 7th Framework Program, the latter was launched in February 2007), and making proposals for the actual themes of the projects or Calls, as well as giving opinion on them, are also basic objectives and fundamental tasks of ETNO.
Through T-Mobile, Magyar Telekom is member of the GSM Association (GSMA) which is a global trade association representing 699 regular members (GSM operators) and 187 associate members (manufacturers and suppliers of devices and infrastructure) across 218 countries of the world. The Association plays a pivotal role in the elaboration of the international roaming rules and the billing and accounting guidelines for settlements among the operators. Our colleagues are actively involved in the work going on in the different groups of the Association, such as in the BARG (Billing, Accounting and Roaming Group), the IREG (Inter-Working, Roaming Expert Group), the DG (Devices Group) and in the TADIG (Transferred Account Data Interchange Group). These working groups, first of all, are elaborating requirements and regulations with mandatory effect for every operator, regarding the interworking of the devices and the networks, the roaming testing of the services, the data exchange required for the settlements, and regarding to mutual settlement itself. Without these regulations it would not be possible to manage the interworking with T-Mobile's 382 networks operating in 178 countries across 5 continents.
In addition to the aforesaid, we have been involved and participating in the work of UMTS Forum and of The Wireless Broadband Alliance as well. The former organization has the task of elaborating standards and recommendations related to UMTS, facilitating the possible widest usage of this system throughout the world. The latter one, is a professional organisation led by Telekom operators. This organisation is dealing with high speed wireless broadband networks with the purpose of elaborating the relevant recommendations and guiding materials.

Common research work

PKI - representing Magyar Telekom - has been participating in two international research associations, namely in EURESCOM and in DSL Forum. While EURESCOM sets up special workgroups to resolve steady or topical problems, DSL Forum rather concentrates on particular issues.
The European Institute for Research and Strategic Studies (EURESCOM) was established in 1992 and since that time Magyar Telekom Plc. has been a shareholder member of it. A considerable part of the European network operators have joined the Institute either as shareholder or as user. Joint developments could deliver in the recent years a number of promising achievements to the shareholders. Nevertheless, while further on keeping in view the business interests, the transformation of EURESCOM from an organisation co-operating based on membership into a modern project managing and telecom consultancy company has begun. During 2006 we have been interested in the following projects:

- P1652 Service Oriented Architectures (SoA) for convergent Service Delivery Platforms.
- P1657 Future Internet - the operators' vision.

DSL Forum, as an international consortium brings together 200 members, such as leading service providers, equipment producers and non-profit organisations. The objective of this international co-operation is to exploit the common potentials and provide full broadband services to the customers on easy-to-use devices, at a price level, which allows satisfaction of mass demands. At present Magyar Telekom has a "Principal Member" status in the Forum and actively involved in the standardization work performed by the DSL Forum. There are two major themes in the focus: the standardization of the architecture of DSL systems and the standardization of the functionalities of subscriber terminal equipment. During 2006 there have been two standards closed: the TR 101 Standard specifying the Ethernet based system technical solutions and the TR-124 Standard specifying the requirements of subscriber terminal equipment. The experts of PKI were participating in the elaboration of the standards' general system technical requirements, the specification of safety technology and multicast based traffic forwarding. We have utilized the results of the work performed in the standardization organization in the introduction of our IPTV service, both in respect of the implementation of its system technology and the definition of subscriber connections.

Co-operations within Deutsche Telekom Group

The development co-operations play an important role in the harmonization of wireline and wireless network development and O&M projects running at Magyar Telekom, Croatian Telekom, Slovak Telekom and Deutsche Telekom, as well as at MakTel. Primarily, the common goal is to ensure a consolidated and uniformed asset portfolio. To achieve this goal launching joint development projects we implement on DT Group level cost optimized network structures, for example, with a common CPE portfolio, or joint preparation of the introduction of new technologies (like VDSL2, GPON) and with the strategic level harmonization of our next generation network (NGN) concepts. The development themes launched with common efforts offer the opportunity of exploiting Group level synergies, conducting efficient financial and human resource management and involving common contractual partners. These common efforts are promoted also by the common Procurement Strategy Framework elaborated for the key technological platforms.

Key R&D indicators

Key indicators of R&D activity of Magyar Telekom Plc.

Within Magyar Telekom Plc. the primary organisational unit pursuing telecommunications R&D activity is PKI Telecommunications Development Directorate. Tasks and functions of this kind have appeared or commenced in the recent years - mostly in the fields of media and communication sciences - at other organisations of Magyar Telekom too.
On 1 March 2006 T-Mobile Hungary Telecommunication Company Ltd. has been merged into the organisation of Magyar Telekom Plc. The financial indicators of the R&D activity performed by Mobile Services Line of Business established within the Company are introduced yet among the relevant data of the Company Group and not on Plc. level. For the purpose of comparison both for Magyar Telekom as well as for the Group the relevant figures are given and analysed not only for the reported but as well for the previous year, too.

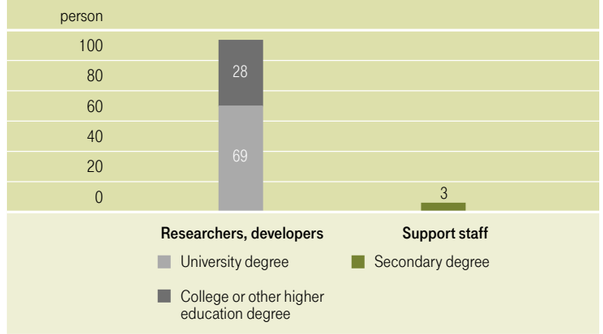
Headcount figures

Compared to the previous year (2005), we have employed nearly the same number of employees in R&D project themes in 2006. The number of FTE-s (full time employees) has slightly increased. The relevant data are shown in the table below.

Magyar Telekom Plc. has a staff consisting of professionals equipped with outstanding professional skills and experience to perform the emerging technical development tasks in the various research-development projects. Magyar Telekom's developers have been regularly participating in several domestic or international conferences and in voluntary training programs organized for professionals. Thus, the on time information obtained on the (technical) novelties facilitate our colleagues to expand their knowledge and keep the pace with the evolution of info-communications. For the purpose of presenting or exchanging the results and experiences obtained in the frame of our research-development works and for the maintaining of our relations we organise conferences and workshops.

Denomination	2005	2006
Headcount employed in R&D themes (person)	106	100
Full-time R&D employees (persons)	32	37

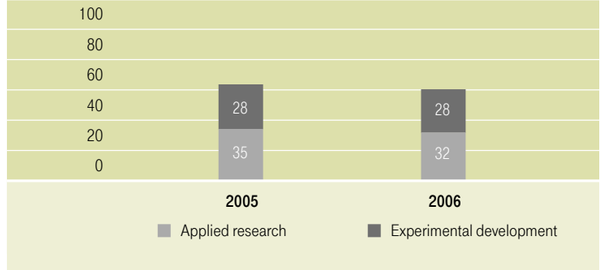
Distribution of R&D headcount in terms of qualification



In addition, our professionals publish their R&D results in Hungarian or international technical journals and scientific newspapers. Over 2006, from our colleagues there have been 18 such articles published in Hungarian, and 4 in foreign language.
97% of those employed in research and development projects have qualifications obtained in a higher education institution (college or university). Many of them have two degrees or speak one or more foreign language(s). From this staff six hold university doctor's degree, from the part-time employed one colleague has Doctor's degree granted by the Hungarian Academy of Sciences and one is holder of Candidate's degree.

Denomination	2005	2006
Number of R&D themes (pieces)	63	60
from which completed: (pieces)	63	54

Distribution of R&D themes



Volume of research and development themes

85% of the sixty research-development themes launched or running in 2006 focused on telecommunications while 15% on the various fields of media and communication sciences.

All of the said themes have been successfully closed and accomplished. The consortium themes financed with the support of program resources, are exceptions, since they are introduced in the report as formally unclosed projects spanning over the coming years. The closing of these themes is expected to take place in accordance with the consortium contracts.

53% of our technical development themes belonged to the category of applied research and 47% to experimental development tasks. Applied research activity aiming at the development of new methods or procedures has been especially emphasized during 2006. Magyar Telekom does not pursue basic research.

Indicators of R&D activity of Magyar Telekom Group

Group-level research and development activities are pursued under the coordination of PKI. At the beginning of the year when launching the themes we jointly formulate - in line with the Company's strategy - the R&D tasks, agreeing upon their professional contents, the targets and objectives to be achieved and the expected results. The development themes launched in this way help us to manage more efficiently and economically the available Group level resources and to involve the resources of our contractual partners.

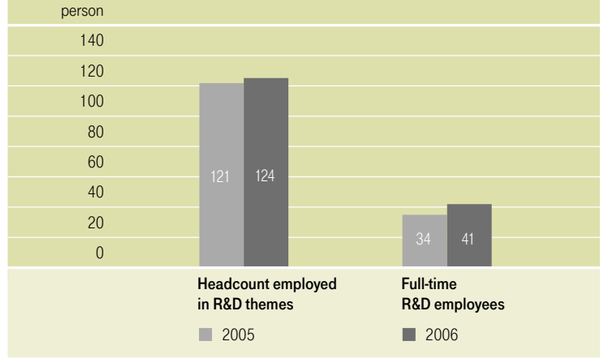
Headcount figures

In comparison with the previous (2005) year, we have employed nearly the same staff in 2006 in the elaboration of different R&D themes. The staff expressed in FTE (full-time employees) has increased by 21%. This change has affected PKI and T-Mobile.
In the interest of optimized utilization of our internal resources we regularly involve the R&D capacities of universities and academic research institutions, too, in the elaboration of the individual research themes. In the future we wish to further strengthen our relations established so far with these partners.

This co-operation forms we consider as one of the fundamental pillars of our future research and development work, since exploiting them we can get familiar with the latest technology developments and in the knowledge of them we can lay down the technical fundaments of new products.

Denomination	2005	2006
Headcount employed in R&D themes (persons)	121	124
full-time R&D employees (persons)	34	41

R&D headcount of Magyar Telekom Group

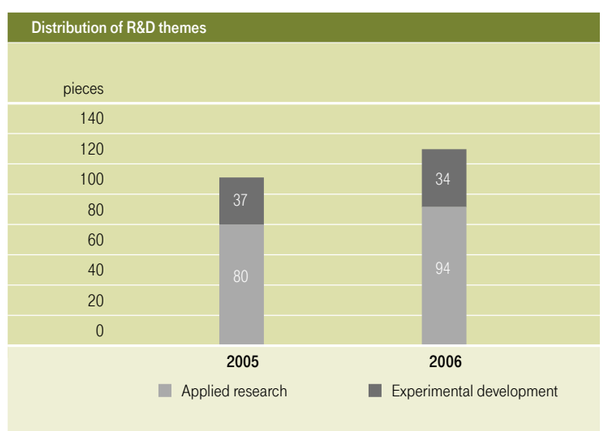


Volume of research and development themes

In 2006 we had been working on 128 Group-level themes and 95% of them had been successfully completed and closed. The closing of the earlier mentioned 6 consortium project themes will be due in the coming years.
73% of the technical development themes consisted of applied research tasks while 27% experimental development tasks.
The projects include five, by the state financed national consortium programs and one international consortium (MUPBED project), where we are working as consortium members. In the frame of co-operations based on bilateral agreements first of all we utilize the expertise capacities of Budapest University of Technology and Economics (BME) and Eötvös Lorand University (ELTE). The results achieved in the frame of our co-operations are utilized and integrated in our short- and middle term development tasks.

Denomination	2005	2006
Number of R&D themes (pieces)	117	128
from which: completed (pieces)	103	122

Distribution of R&D themes



Outlook

All over the world the role players of the business life encounter dramatic changes and serious challenges at the same time. They have to meet from day to day newer and newer economic, social and cultural requirements. The same applies to Magyar Telekom, too. There are long-term trends behind the significant changes to the traditional telecom business, prognosticating stable revenues but declining margins. The growth of major Western European incumbent telecommunications companies is fuelled mainly by acquisitions coupled with aggressive broadband roll-out and strong cost control.

The trends of the Hungarian telecom market are quite similar to those ones of Western Europe, however there are several specific factors characterizing the Hungarian telco business environment to observe. The Hungarian telecom market is facing a changing competitive battlefield primarily because of the 'land grab' attitude of competitors appearing in the market with different economics. In this situation Magyar Telekom has redefined its strategic objectives aiming at the sustaining the competitive edge for the Company and for the individual lines of business.

It is a basic standpoint for Magyar Telekom to continue in the future too its efforts and in the interest of the society and of its own strive for making available the latest accomplishments and feats of telecommunications and IT industry for the widest circles of its customers. With the aim of finding the best solutions we exploit our own innovation results and achievements of our partners, too.

So far our Company was known among the people as a company providing telecommunications (telephone) services. At the same time, the reducing number of fixed line subscribers forced the Company to try to preserve its competitive edge through innovative developments. Thanks to them, by to day we have been offering several IP based non-voice products. We wish, however, to go ahead from this situation and have to transform the Company into a multimedia provider.

Through laying down the technical fundaments for the Company Group's future business successes our strategic goal is to ensure that we are involved producing the possible highest add-on-values in the domestic and international market economy and by that determine the long-term trends of telecommunication industry. For this purpose, utilizing our knowledge intensive research and innovation activities we wish to get on and be successful in the competition environment, too. Our innovation activities focus basically on the obtaining of new scientific knowledge, on efficient research and entrepreneurial partnerships and co-operations, and as well - making use of the obtained knowledge - on the development and bringing to market of new products and services.

Magyar Telekom Group's markets of core operations imply only slight increase, whereas surrounding convergent markets imply stable growth on the long-term. Entry barriers between the individual markets and market segments are continuously being eliminated. Thus, Magyar Telekom can hopefully reach these market segments from a strong and favourable position.

For setting foot on the new market segments we have to implement the country's most up-to-date, fastest and most efficient telecommunications network infrastructure enabling us to provide higher bit rate demanding broadband services meeting the highest standards of quality and reliability. We wish to achieve a leading position in the provisioning of media contents, supplementary and interactive services, as well as in cable television, IPTV, digital programme broadcasting and mobile TV.

Our innovation activity establishes the successful fulfilment of the objectives outlined above. At the same time, we take into account it, too, that Magyar Telekom Group as a leading info-communications service provider has been playing a leading role in Middle Europe in the field of environmental protection, too. We wish not only to maintain this position but to achieve the same position also in the field of sustainable development.

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