



Magyar Telekom Group's  
Research and Development Activity  
2005

# Contents

02	Introduction
04	Research and development activity of Magyar Telekom Group
04	Overview of R&D activities
07	Key R&D themes
07	NGN-based developments
08	Multimedia developments
12	Wireless network development efforts
14	Development of VPN solutions
14	xDSL technologies
14	Security solutions
15	Fixed line – mobile convergent products
15	Optical systems
15	Development of network design methods
19	R&D Consortia
19	Adaptive media stream service architecture for the latest mobile telecommunications systems
20	Establishment of Mobile Communications Research Developing and Innovation Centre - Mobil 2004
20	MUPBED
20	GVOP 3.1.1 (Services over advanced optical networks)
21	GVOP 4.4.2 (Construction of broadband network infrastructures by self-governments)
22	Additional R&D activities
30	Exploitation of R&D results
31	Domestic and international R&D co-operations and relations
31	Domestic co-operations
33	International relations
33	The role of our events in our relations
34	Key indicators of R&D activity
34	Key indicators of R&D activity of Magyar Telekom Plc.
36	Key indicators of R&D activity of Magyar Telekom Group
38	Outlook

# Introduction



The role of science and research is changing from the point of view of global competitiveness. Scientific knowledge constitutes a considerable part of the knowledge material relevant to competitiveness, and basic research perceptions play an important role in that. At the same time, the importance of skills and abilities is growing as well that can be obtained and deepened only with a scientific attitude and mostly by actively taking part in scientific research work. Utilisation of problem solving abilities and the using of modelling techniques become more and more common. By today science has become an important quality factor of our life.

Through laying down the technical fundamentals of 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 we determine the long term tendencies of the telecommunication industry. Using up our knowledge intensive research and innovation activities we wish to get on and be successful in the competition environment, too. Our innovation activities basically focus on the obtaining of new scientific knowledge, on efficient research and entrepreneurial partnerships, co-operations, and - making use of the obtained knowledge - on the development

and bringing to market of new products and services. Recognizing the fact that the regional knowledge centres organizing themselves around universities and research institutions, the national research laboratories, the industrial parks, the logistics centres and the incubator houses specialised in state-of-the-art technologies constitute important pillars of the national innovation system, Magyar Telekom Group performs R&D activity in several domestic and international consortiums resting upon mutual benefits of cooperation.

Within Magyar Telekom Group research and development activities are carried out in a co-ordinated manner. We harmonise the intended themes already in the planning phase and the member companies involved in the given theme maintain regular or continuous contact with each other in the course of the elaboration, implementation. In the interest of laying down the fundamentals for our future-oriented, knowledge-intensive developments we regularly make available for the public our achievements and results.

Looking back to the last 10 years, all important network and product development projects implemented by Magyar Telekom were always preceded by proactive R&D activity that greatly contributed to the on time, economical and quality implementations (for instance: network

digitalisation, ISDN, No. 7, ATM, IP, ADSL, VoIP, Ethernet technologies, etc.) and to the introduction of services, such as IP Complex Plus product family, WLAN and IN products and digital CATV).

Our present R&D activities focus on the obtaining of core input information forming the pillars of the middle- and long term technical and strategic platform developments of Magyar Telekom Group. One of the most important elements of them is NGN (Next Generation Network), the future's convergent network the application of which will become a necessity in the near future.

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 introduction of the Company Group's performance and relations in domestic and international R&D consortiums and other national and international organisations. Thereafter, we describe our other R&D activities and - by means of some selected key themes - illustrate how we utilise in the daily business the R&D results and knowledge obtained. At the end of the Report we give some key financial indicators on the Group's R&D activities and an outlook including our ideas for the future.

# Research and development activity of Magyar Telekom Group



## Overview of R&D activities

All over the world the role players of the business life encounter serious challenges, since they have to meet new economic, social and cultural requirements. Adaptability to the ever changing market environment and the ability to satisfy the society's newer and newer challenging requirements are 'a matter of cardinal importance' for the companies. Magyar Telekom, too, is one the players shaping this market environment. Under the given challenging conditions the Company wants to strengthen its leading position achieved in the telecommunication sector via the optimal exploitation of the financial, economic and technical results of R&D. The following chapters give a short overview and summary of those highlighted themes by the realization of which we intend to achieve our strategic targets. Our research work aiming at the creation and implementation of new platforms and the introduction of the future's convergent network we rank among our most important R&D tasks. In the frame of the ENUM (tElephone NUmber Mapping) Project, being executed among the NGN based developments tasks, we have created such a pilot (test)

system, which allows to assign ENUM identifiers to users and to access them at several different addresses. A web based graphical user interface is provided for both administration and the management of user profiles. We have tested the signalling protocols of the third generation mobile networks with the aim of possible combining of wide range of next generation services with geographical mobility and relatively big, dynamically distributable bandwidth. In the field of the further development of IP telephony services, applications and prototype, with the upgrading of the existing experimental system we have implemented the integration of hardware-based telephones. We have elaborated such a QoS measuring method, with the help of which the quality of the VoIP (Voice over IP) service can be tested and measured on a relative scale, and the given test results can be compared. A special case of mobility is the so called nomadic mobility, when the user - who is on the move - is not connected to the network. Combining the standardized SIP protocol with the solution of Skype Company we have made a proposition for such architecture, in which also clients hidden behind the firewall can use the SIP protocol for VoIP communication. Due to the present, widely used address translators and firewalls, we have had to apply

flexible techniques, i.e. the address translation and firewall mechanisms used in a particular case formed a core element of the solution. For two cases, which we have considered to be critical for SIP, we have developed a detailed solution. The services resting upon multimedia-based communications form a key element in the development strategy of Magyar Telekom. The research activities performed in this field have had the aim of making available for the future's households such value-added services that are based on home broadband access. With the implementation of the digital home concept, several supplementary elements can be added to the service portfolio provided currently to the customers, including IP-based communication provided on fixed or wireless networks, or forwarding on the same networks of audio and video, or other, for e.g. control, signals. Under laboratory test conditions in Ethernet environment we have tested DRM (Digital Rights Management) systems necessary for the implementation of triple-play (integrated voice, data and video) service via broadband access. Within the frames of this theme we have studied the rights management of digital content distribution, and on a (prototype) lab test system the characteristics related to content protection and distribution and authorisation.

To form out our vision on triple-play, we have made a study, giving an assessment on the status of the relevant technologies and services and on the international trends. In the study, besides summarizing the current technical possibilities, we have identified and evaluated the key aspects of becoming a triple-play provider. We have addressed issues, like: infrastructure development needs, CPE-s, content provisioning, system integration, CRM-specific tasks and regulatory aspects. With this work we have contributed to the planning and establishment of a new technical-service framework. Spreading of wireless technologies has not only continued in 2005, but beside the existing WLAN, studying of a new solution (WiMax) has commenced, too. Compared to WLAN, which is primarily designed for Internet access, WiMax with its integrated QoS (Quality of Service) features and being applied not in the ISM-band is a suitable technology for provisioning of leased-line like services for business customers. Though, the technology is yet in standard implementation phase, Magyar Telekom has already announced its new WiMax technology based service. In the interest of it, we have created a test environment and have carried out on it system integration tests preceding general rollout.

In the frame of our examinations aiming at the introduction of fix-mobile convergent products we have identified and specified the possible technical solutions, the applicable terminal equipment, the requirements of providing expected voice quality and those convergent products that are already available.

Optical transmission technology is determinant in the backbone network of Magyar Telekom. Besides assuring the required quality, the raising of transmission speed and increasing of capacities are of key importance. Learning about the physical factors influencing the transmission quality in high speed optical systems aimed at the compliance to these aforesaid basic requirements. For this purpose, we have sized up the attenuation and dispersion parameters of DWDM backbone network and made a proposal for the modification of the values of the compensating elements in the network.

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 the above written we have elaborated an analysis methodology enabling us to obtain information on the reliability of T-Com's IP network, and we have further developed the methodology for detecting and localizing bottlenecks of IP network, too. We have analysed and optimised the utilisation of free capacities available in the transport network. We have elaborated planning methods for network traffic engineering and system technical optimization of Ethernet network. We have worked out the planning methodology of the new generation WDM transmission network. Our studies included also the analysis of applicability of Ethernet PON and Gigabit PON in access networks.

Magyar Telekom Group consciously makes efforts to replenish or multiply its existing - whether professional or financial - R&D resources. Foundation of R&D consortiums offers splendid opportunities for the involvement of additional resources. A R&D consortium is a company form having no legal entity, which is based on voluntary assumption of obligation of its members and set up exclusively with a dedicated professional objective. The founders - in the interest of execution of the project and achieving the set target - act jointly in different tenders for obtaining additional resources to supplement their own ones. The budget of the consortiums consists of the founder's financial, human, laboratory instruments and other assets and it is supplemented with resources won via tenders. A considerable part of tender invitations

of NKTH (National Office for Research and Technology) or the EU tenders provides resource winning possibilities for consortiums with defined composition only. This principle is asserted by the supporter(s) through the evaluation scoring/criterion system communicated towards the applicants. In the past the supporters have preferred R&D consortiums that have been established under the leadership of institutions of higher education and with the involvement of industrial partners for the achievement of a dedicated professional target. Further on we will 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. 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 later chapters.

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 or 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 Institute of Magyar Telekom Plc. In addition, we utilize the above in product developments, in tendering and equipment certification procedures and in O&M support.

## Key R&D themes

### NGN-based developments

#### Further development of ENUM pilot system

With ENUM (tElephone NUmber Mapping) developments we have set the target to create such mechanisms with the help of which the accessing the subscribers via a traditional telephone line can be extended to IP as well, using DNS names. The purpose of ENUM is to form DNS names from telephone numbers; as for the DNS names, they are to orientate us on how the called party can be accessed. One of the alternative access methods is the addressing using SIP protocol, but a mobile phone number or even an e-mail address can also be given. In the frame of ENUM R&D Project we have developed at PKI a pilot ENUM system, which allows to assign ENUM identifiers to users and to access to them at several, different addresses. The system can be used for the time being only with software 'user agents', because of the applied security protocols.

The pilot ENUM system has been made stronger from security points of view and the first phase of client interworking tests has been closed with success. Within the frame of this theme, we have participated also in the ENUM Project of Deutsche Telekom TCC (Technology Competence Centre).

#### Signalling protocols of 3rd Generation mobile networks

Magyar Telekom's voice services - whether fixed or mobile - have to be able to meet growing competition, since Skype and other global VoIP service providers gain stronger and stronger market positions.

In the initial phase of our developments we have set the target to create an IP-based call set up solution for voice transmission also in mobile environment. UMTS Release 5 Recommendation defines as signalling protocol the SIP protocol, which is a dominant protocol in the NGN-based VoIP networks being developed by us, as well.

The result of our developments was the making of a Windows Mobile and Windows CE based SIP dialler software that can serve as a basis for the introduction of IP-based mobile voice communication services.

#### Protocol communication development

At the beginning of the XXI Century it becomes a natural demand that people can communicate with each other as variously as possible. A special form of communication is the non-real time information transport, via messages. The purpose of our protocol communication research studies was to find a unified system, with the help of which the various message types (e-Mail, Voice-Mail, video,

facsimile, etc.) can be uniformly handled: this system is the Unified Messaging System (UMS).

In the frame of this research work we have deeply analysed the UMS protocol, within the Fix MMS R&D project we have provided a solution for MMS - e-Mail conversion, and in the frame of R&D theme "Telecommunication for injured people" we have presented a demo SMS, MMS, e-Mail text to speech converter. Our results can be important building blocks of the future's communication services.

#### Upgrading IP telephony services, applications and prototype

Continuing our IP telephony related developments we have set the target of upgrading our experimental system developed in 2004. System integration of hardware based telephone sets was a primary requirement, since so far in case of address translation only certain software based telephones could be used.

Thanks to these developments, most of IP telephone sets, or integrated broadband terminal equipment supplied with traditional telephone connection interface, interwork with the experimental network. The problems with address translation we could resolve with appropriate configuration of the central controller, without the use of Session Border Controller (SBC). One main lesson that can be drawn from the research work is that integration of SBC is recommended in the interest of increasing scalability.

#### QoS methods in IP telephony environment

For IP-based telephony, provisioning of high quality of voice transmission requires circumspect and careful planning. The quality of transmission depends on the algorithm applied at the voice compression and on the transmission parameters of the IP network (delay, jitter, etc.). The development aimed at the elaboration of such a method, with the help of which the quality of the voice transmitted over IP can be monitored.

The study produced in this scope introduces a QoS method, with the use of which the quality of VoIP service can be tested, measured according to a relative scale, and thus the comparison of the given coding methods, devices, network fault impacts is also possible. Using these measurements, the customers of Magyar Telekom in the future can avail themselves with VoIP services with precisely determined quality.

#### Support of Nomadic mobility

A special case of mobility is the so called nomadic mobility, when the user - who is on the move - is not connected to the network.

An average laptop user can hardly concentrate on his

work, while he is on the way. He needs network connection only when he stopped and can pull out his laptop from his bag. For instance, such typical places of temporary, nomadic presence are the public WLAN Hot spots located in airports or cafeterias, or connection points made available by companies for their business partners visiting them. In the course of our developments we have analysed the possibilities of providing VoIP connection for such “wandering” subscribers.

Combining the standardized SIP protocol with the solution of Skype Company we have made a proposition for such architecture, in which also clients hidden behind the firewall can use the SIP protocol for VoIP communication. Due to the present, widely used address translators and firewalls, we have had to apply flexible techniques, i.e. the address translation and firewall mechanisms used in a particular case formed a core element of the solution. For two cases, which we have considered to be critical for SIP, we have developed a detailed solution that we can apply in the case of services to be introduced in the future.

#### Multimedia developments

##### System technical aspects of Multicast support

Unicast based techniques do not allow performing efficient media distribution or content broadcasting on IP networks. Our research in the scope of this R&D theme had the purpose to find possible solutions for multicast based content provisioning in MPLS VPN environment. Our analysis in connection with multicast techniques has covered the studying of the network traffic reducing impacts, as well.

The multicast based solution described in the study prepared in this subject, makes it possible for the providers to forward multicast traffic in MPLS VPN environment, that is to determine the path of the multicast package and forward it separately to every and each VPN routing and forwarding (VRF) instance, and also over the provider's backbone network.

These research results have influenced the forming out of the triple-play architecture, too. Multicast transmission on MPLS network can be realized in IP packages having no MPLS label. The MPLS VPN based solution designed for multicast provides the possibility of secure content distribution among the sites of a service provider.

##### Multimedia in the homes

Households of the future will be characterised by the dominance of such value-added IP based services that are based on home broadband access, but regarding their capabilities go far beyond the possibilities offered by traditional Internet. We have searched such possibilities of development and system integration that enable the

implementation of our so called “digital home” concept.

The study produced in the frame of this research work provides solutions for the possible interconnection of different fixed line and wireless technologies, for the integration of remotely controllable electronic appliances, as well as gives answers to challenges of home networking of different user facilities and their safety and automated interworking.

The developed virtual home on our Internet website introduces the functions and features implemented during this development work. The solutions developed herewith (remotely controlled household appliances, home security system, “multi-play” media services) may appear in the future in more and more households.

##### Multimedia services in Ethernet environment

IP-based media distribution requires careful planning of content protection. The purpose of the research is to develop solutions for the protection of content transmitted digitally in media distribution. Within the scope of this theme - in the frame of lab tests - we have carried out the testing and comparison of DRM (Digital Rights Management) systems necessary for the implementation of triple-play (integrated voice, data and video) service with broadband access. We wanted to get answer to questions concerning how the most up-to-date coding methods support the legal and access protection of the transmitted content and how this protection can be implemented in case of using the different coding methods.

In the frame of this theme we have studied the handling of content distribution rights and made a comparison of such solutions. In addition, on a laboratory test system we have tested a prototype. Our tests included:

- the protection of the content, the mandatory and required application of copyright and broadcasting related legal provisions,
- the distribution of live and stored video content produced with different coding, to the authorised users,
- the protection of rights and the protection of digital content.

The results of our research have been incorporated among the security solutions of the IP based media distribution system being introduced, thus we can minimise the volume of misuses concerning media contents.

##### Video signal transmission in studio quality on Ethernet network

The development aims at the working out of system technology of IP based program transmission in studio quality. As conclusion of the research study can be stated, that a video signal from the different spots (e.g. from a concert) can be efficiently transmitted up to the studio

with high bandwidth, Layer 2, transmission. The video signals incoming at the head end station are processed by the video encoders and streaming servers of the local Ethernet network and then forwarded towards the IP backbone network.

The study prepared in the frame of the theme introduces the additional tasks of the head-end station, too, like for instance, the authentication and the forwarding of the video signals to other platforms (for e.g. triple-play). Bringing studio quality video signals demanding high bandwidth to the head- end station is a fundamental issue, not only because of the general requirement of QoS enhancement, but also from the point of view of signal transmission requirements of future HDTV (High-definition television) platform.

We have utilised our development results in the development of the system architecture of triple-play. Moreover, the solutions developed within this research work can be well utilised in later HDTV content distribution developments, as well.

##### Comparative analysis of broadband

##### Internet service codecs

With the spreading of broadband access the demand for and the possibilities of multimedia and transmission of multimedia (image, voice and text information) contents have grown as well. During the research work we have

analysed the latest media coding methods in terms of their sensitivity to network errors, their bit rate demands, or their impacts on subjective perception.

The study elaborated by us in this theme gives an analysis on the currently marketed competitive coding methods, in view of the possibilities of the different broadband access techniques (for e.g. ADSL/ ADSL2/ ADSL2+/ VDSL2, WLAN/ WiMax, etc.). In our work we have paid special attention to the error tolerance of the coding methods, their portability and their perspectives. We took into consideration our research results in the planning of the IP-based media content distribution architecture and in the device selection. The results of measurements performed during the development we have utilised in the optimisation of service quality.

##### Development of Triple-play system technology

In the frame of this development we have laid down the technical fundamentals of service suitable for VoIP transmission of data and video. We wanted to get answer to the question, how the today yet heterogeneous IP based environment, technologies can be interconnected, integrated and be made portable.

For this purpose we have tested and studied the triple-play devices, platforms produced by different manufacturers, the protocols and standards applied in triple-play transmission and the interworking of coding methods.



In addition, our work has covered the studying of access types (xDSL, Ethernet, WiFi, etc.) and interconnection solutions of the different end-user equipment (Set-top-box, xDSL modem), too.

We have utilised our results in the implementation phase of triple-play system technology and in our vendor co-operations.

### Triple-play vision - Impact of technology convergence onto content supply strategy

In the frame of this theme our investigations focused on the impacts that technology convergence has on content supply strategy. In other words, our research had the aim to analyse - namely from the perspective of the content supply strategy of a telecom service provider - the long term impacts generated by the convergence of IT, telecommunications and content industry.

Within this study work, we gave an assessment on the status of the relevant technologies and services and on the international trends. In the study, besides summarizing the current technical possibilities, we have identified and evaluated the key aspects of becoming a triple-play provider, too. We have addressed issues, like: infrastructure development needs, end-user equipment, content provisioning, system integration, CRM-specific tasks and regulatory aspects. With this work we have contributed to the planning and establishment of a new technical-service framework.

### Implementation of the prototype of VoIP based voice transmission system working on cable television networks (VoCaTV)

The results of preliminary market surveys show that there is a considerable demand that Magyar Telekom should appear as alternative service provider in LTO areas. In the study made on the basis of our researches we have investigated the possibilities of implementation of IP based voice transmission via CATV networks.

The study provides a solution for voice transmission over CATV, reviews the current standard technologies and analyses the service potentials of these technologies, too. Based on the statements and conclusions of the study work, we have implemented a test bed under laboratory conditions. The commercial product that was developed taking into consideration of the results of the R&D work, was successfully introduced - after a nearly two-months pilot operation - by T-Kábel in July 2005, first in Szeged and then in other bigger cities as well. The number of customers has exceeded all previous expectations, thus we have had to put to further loading test the system's soft-switch, so that to be able to ensure operational safety of the service even with growing usage demand.

### Performance tests of Radius accounting server

The research work had the purpose to develop a prototype of such a universal measuring, monitoring system, with the help of which the operation and the efficiency of RADIUS protocol becomes traceable or controllable. With our solutions we have tested as well how the performance of UDP (User Datagram Protocol) can be maximised. A study has been written on the testing of the protocol's reliability. In the study we have made proposals for the elimination of deficiencies detected with the protocol and have specified measurement methods for the identification and determination of quality parameters. These methods can be very well applied in every such environment, where the reliable operation of RADIUS protocol is a fundamental condition.

### Security risks of Ethernet VLAN applications

For the provision of ADSL-based services Emitel's service area has become by today almost fully covered by Ethernet backbone network. Besides broadband Internet, this network provides backup infrastructure for other types of data communication services, as well. The independent services are separated from each other with the help of application of virtual LAN-s (VLAN-s).

The purpose of the project was to investigate the security of VLAN if applied on Ethernet backbone network and to make proposals for justifiable security measures. The study prepared in the frame of this theme gives an analysis on security solutions implemented in the different network layers. On the basis of the study, in the laboratory network installed in Emitel's exchange in Kiskunhalas the various forms of attacks and protections were demonstrated. All in all, it can be stated that Emitel's Ethernet backbone network (incl. DSLAM-s) is operating at appropriate security level, even with the application of VLAN-s.

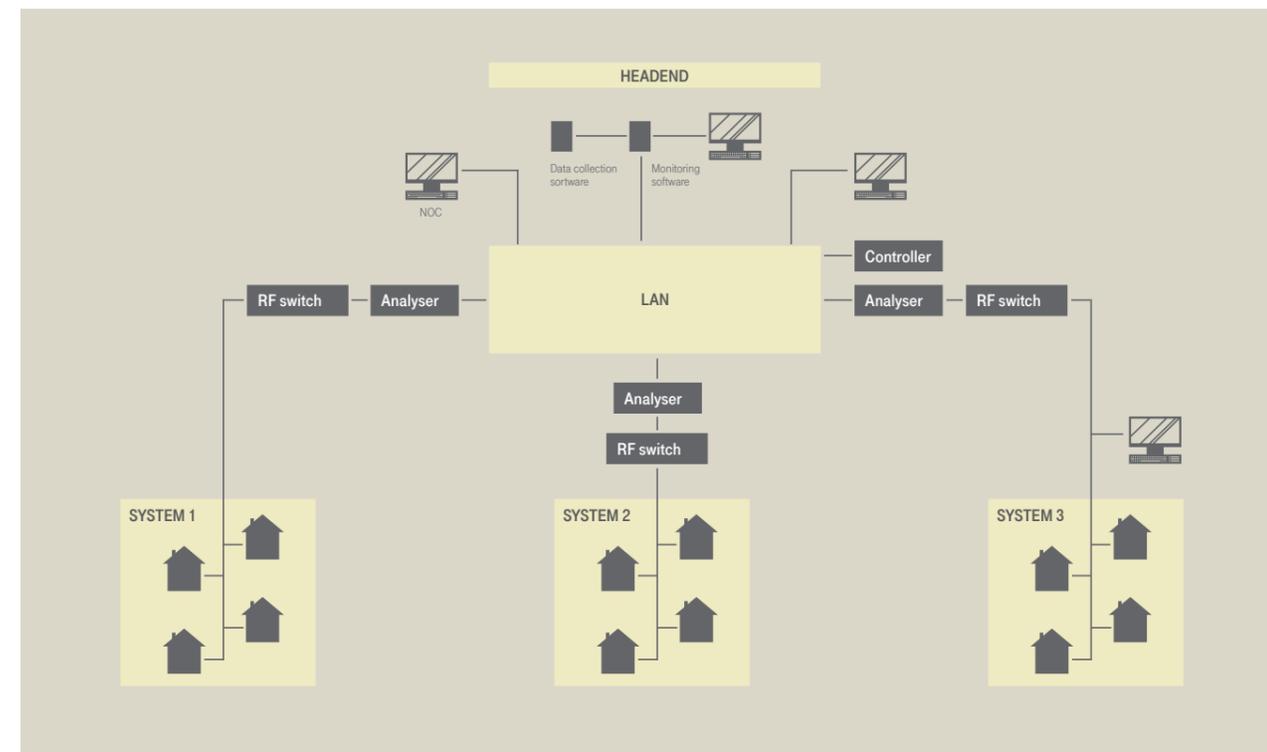
### Improvement of Customer Care Support Model

The project has aimed at the creation of such a system, which on the basis of the data of the existing databases models the customers' behaviour in connection with the occurrence of different events.

The model is applicable for the identification of customer segments, or groups and at the same time the software framework continuously updates the learned churn characteristics and it is able to continuously supply the data-warehouse with churn probability data.

### Analysis of DVB-C transmission, development of testing devices, their applicability and limitations

In the scope of this research work T-Kábel has established a development laboratory in order to support digital DVB-C technology to be introduced in its service area. We have



installed in the development laboratory an experimental test bed system - based on digital DVB-C technology. The test bed system, which consists of several devices, is capable to receive and analyse DVB ASI standard signals, and it can perform ASI-IP and IP-ASI conversion, and OFDM-ASI conversion. It includes 8 devices that are suitable for multiplexing of ASI signals and production of QAM signals, providing the possibility of creation of test-type digital streams.

As the result of the performed R&D development activity, there has been the prototype of the flexible digital signal source implemented, which was applied in the measuring of system parameters and signal transmission measurements of the digital streams, or in the tests performed on selected set-top-box.

### Analysis of management possibilities of CATV networks

The R&D activities performed in this project have had the purpose to find a solution, how the level of operation of cable television networks can be improved by enhancing the availability/reliability of the appearing new services and by preventive detection, localization of network faults. The study deals with the supervision and manageability of cable television networks and equipment. As a solution for the management of IP devices the study introduces a network operator centre (NOC) - that operates fully based on IP technology - and that is able to monitor in a 24h regime the whole CATV network (both the optical and the coaxial network layer) and the IP-based network

as well, even with the possibility of active intervention. After giving an overview upon the management systems, the study gives an analysis of the current management system of cable television optical networks operating in Budapest and makes proposals for its further development. With the implementation of the proposals the higher availability necessitated by the introduced new services can be fulfilled and the solution opens the way for preventive maintenance activities, too.

### DVB-C image transmission in analogue environment, cross-interference testing

Digital signal transmission (DBV-C), which appears adjacent to analogue channels over T-Kábel's network justifies the performing of neighbouring digital/analogue channel tests, and the analysis of its impact on video transmission characteristics of various TV sets within that. The purpose of the study produced in the scope of R&D activity was to verify theoretic deductions, as well as to learn how television set receivers of different makes behave if an interfering signal of high level (DVB-C signal) appears next to the selected channel. We examined the neighbouring channel signal-to-noise ratio values for several (-13 dB, -6dB, 0 dB, +10 dB, and +16 dB) digital/analogue signal level ratios in the course of the measurement series.

We examined the signal-to-noise ratio of neighbouring digital and analogue signals that are aggregated with different signal levels and fed to the RF-input with some

typical TV sets, measured on the TV set's video output. The series of measurements produced results that can be adapted to cable-TV practices, which provides the basis for formulating an optimal channel-allocation strategy.

#### Examination of user habits

Tests that investigate user habits on the basis of registering eye movements have been known for a long time. Recently, however, eye movement registration methods have achieved a convenience, and availability level that allows ever increasing use of them for the examination of web-based stimuli.

The method is based on eye movement pattern measurement thereby offers the opportunity for identifying such specific visual characteristics that attract attention the most within a given stimulus environment, and are therefore able to influence the efficiency of processing specific visual or textual elements, along with the probability of their conscious perception.

The research procedure that was applied appears to be suitable for testing the effectiveness of advertisements, and advertisement surfaces, as well as for determining what kind of advertisements should be placed, in what position, and with what features on the pages triggered by specific content, and the search strategy defined in this manner.

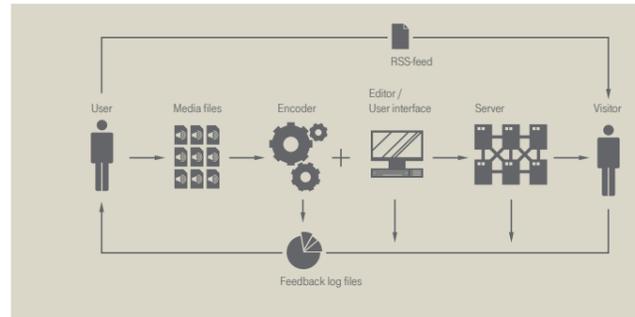
#### Possibilities for formulating a media processing and database system for the "Video Blog" application

Blogs are an ever increasingly popular form of providing news, as well as publishing via the Internet. Video-blogs – which are replacing sites that typically have text content – appeared as user bandwidth increased. The outcome of this research became a database based flash video conversion and video-blog test system that is built around the http-protocol, and which supports an input format that is as widely spread as can be.

We constructed a test system as part of the research, and it is made up of the following units:

- transformed blog-engine, which makes it possible for users to upload video files in different formats, as well as to integrate them into databases,
- database monitoring encoder, which generates flash video files with desired profiles after determining format.

The clips prepared by users are stored on the server, from where users can insert them into their blog, and visitors can browse the video clips that are ready, adding comments to them as well.



#### Wireless network development efforts

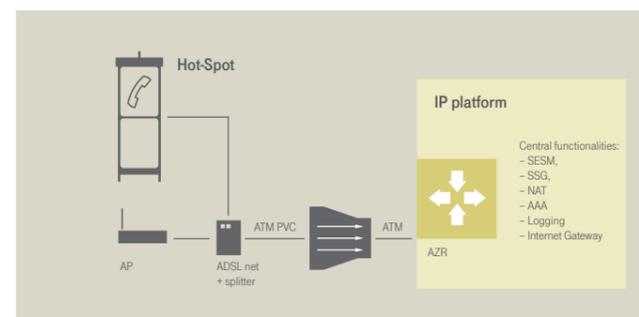
The dissemination of wireless technology not only continued through 2005, but beside the existing WLAN the examination of a new solution (WiMax) was also commenced. As opposed to WLAN – which fundamentally is suitable for accessing the Internet – WiMax, with its integrated QoS capabilities, and positioning outside of the ISM-band, is especially suited for providing leased-line like services to business customers. Although the technology is still in the standard implementation phase, Magyar Telekom has already announced its new, WiMax-technology based service.

#### Key WLAN-based technical development activities during year 2005:

T-Com's WLAN-service (previously referred to as the EasyNet, currently called the HotSpot service) is undergoing continuous improvement. The prototype for the new logon interface was developed as part of this process in connection to technical enhancements, the centralised AZR (Access Zone Router) functionality was deployed, the prototype for the 15-minute prepaid card was completed, furthermore the exclusion of 30-minute, as well as 1-hour prepaid cards from roaming was implemented.

#### New logon interface:

Modifying the logon interface so that the selection of roaming partners becomes easier, apart from reflecting the altered image characteristics became necessary in connection with re-branding, and the requirements of the roaming functionality. Therefore the possibility to select



a roaming partner was changed to a pop-up window solution on the one hand, and successful logon was linked to accepting subscriber terms and conditions on the other, this being the technical adaptation of a legal requirement. Websites available free of charge were also restructured in the interest of achieving a clearer layout, along with the service use description.

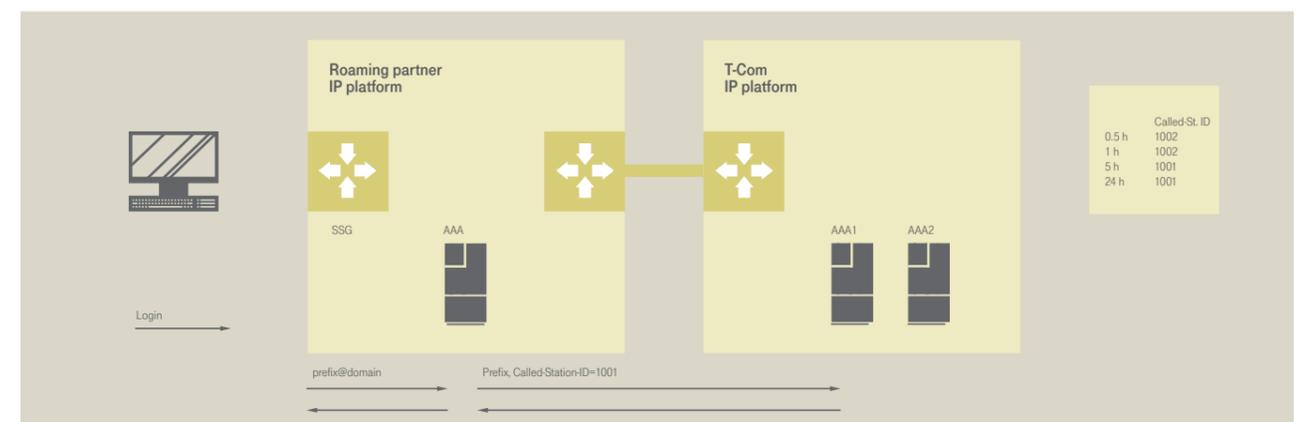
#### Centralised AZR-functionality:

One of the new types of access solutions includes what is referred to as the centralised AZR functionality, which first and foremost facilitates the utilisation of telephone booths as HotSpots. There is extraordinarily little room in phone booths for the installation of telecommunications devices, what is more, power supply, and the appropriate climatic conditions also need to be provided for. The purpose of this research was, therefore, to elaborate a solution

which facilitates the placing of such devices in switches. With the help of the centralised AZR-functionality the router – which by default is placed at the HotSpot or the phone booth – is installed at the service provider's site, therefore a single AZR can be associated with even several sites. The prototype that was created satisfied security requirements apart from meeting the basic criteria of proper operation. The diagram at the bottom on page 12 shows the implementation of the AZR-functionality.

#### Creation of the prototype for 15-minute based prepaid cards:

The HotSpot (EasyNet) service used second-based prepaid cards ever since the time it was launched. The motivation for development is primarily derived from business considerations. Demand has appeared for prepaid cards which work with 15-minute units for



settlement. As a result of technical development activity, cards operating with 900-second, that is 15-minute units of settlement have been created.

Exclusion of 30-minute and 1-hour prepaid cards from roaming:

Business models that impact the HotSpot-s, as well as the various roaming partners make it necessary to exclude the given prepaid card types from roaming in certain cases. Research came up with a proposed solution for this problem.

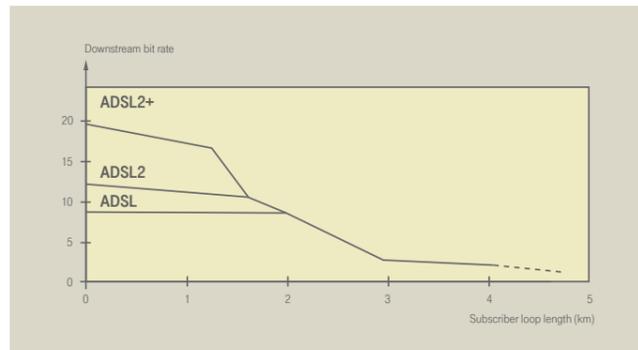
Instead of simple domain-based filtering or exclusion, the use of what is referred to as the Called Station-ID attribute was targeted in the course of development, in a manner so that when 0.5 and 1-hour cards are used, this attribute is given a value that is different from the rest of the cards. The diagram at the bottom on page 13 shows the model for excluding prepaid cards from roaming.

#### WiMax test environment

WiMax technology is applicable in addition to the existing fixed line infrastructure in places where there are technological and/or economic reasons that prevent the extension of broadband fixed line networks, or when the regulatory conditions do not allow other solutions (e.g. in LTO areas). WiMax networks are suitable for carrying services according to "triple-play" concept, i.e. the circle of services that can be provided by WiMax includes broadband data transmission, voice transmission and moving image transmission.

The purpose of WiMax R&D project is the preparation of WiMax services anticipated by T-Com. To achieve this goal required analysis a series of interrelated technical, financial and legal/regulatory aspects. It was necessary to implement a pilot system, as well to carry out the most relevant measurement and functional tests.

During this project we have performed radio tests, both outdoor and indoor. As for the indoor tests, we have put emphasis to the testing of the manageability of interfaces and to the functional testing of the system. Our outdoor (in situ) tests were performed with the aim of testing of radio parameters, since we had already tested the base band characteristics when performing our laboratory measurements. On the basis of experience gained from the measurements that we performed in big city environment for testing the NLOS (Non-line-of-sight) feature of WiMax, it can be stated that quite acceptable reception quality can be achieved on higher stores even of hidden buildings.



#### Development of VPN solutions

Spreading of IP VPN (L3VPN) has raised more and more often the need of replacing of the existing leased line based OSI Layer 2 virtual private networks (L2VPN) by much sophisticated solutions that similarly belong to OSI 2 Layer.

In the course of developing VPN solutions, besides sizing up the possibilities, we have carried out EoMPLS, VPWS, VPLS and QinQ protocol test measurements, too.

These research activities create the grounds for the introduction of the – from the point of the future determinant – Layer 2 based techniques, replacing leased line.

#### xDSL technologies

The traditional twisted copper pair continues to be a determinant element of access networks. It could become the most common physical medium, because its construction has started much earlier. Systems of the past have been improved in efficiency through numerous innovations and the appearing newer and newer technologies offer further possibilities for the providers.

In the frame of this research we have analysed the possibilities of new generation xDSL technologies (ADSL2, ADSL2+, SHDSL, VDSL2). Achievable bandwidth, reachable distance and the triple-play related features of equipment were in the focus of the tests. Moreover, we have carried out analyses and measurements to identify the conditions of system integration of DSLAM-s with Ethernet uplink.

Thanks to the researches Magyar Telekom could determine already in the early phase of the technological developments those solutions which – though mostly for short distances – make it possible to reach very high bandwidths. These researches can serve as a basis also for later upgrading of the triple-play system.

#### Security solutions

##### Managed Firewall – solutions that can be offered to subscribers

Nowadays a computer with online Internet connectivity that is installed at home is exposed to up to several dozen,

frequently even several hundred network attacks every hour. Effective protection against such attacks requires IT-skills that most users simply do not possess. Centralised firewall solutions entail one of the main directions for development. With the help of such solutions, it is possible to protect subscribers' computers against unauthorised access by means of control through a central router, without detailed local configuration. Analysing the possibilities in SSL-based VPN-s constituted the other direction for development efforts. Investigations extended to comparisons with existing VPN-solutions, as well as issued related to mobility. The study established that SSL is supported by Internet-browsers, therefore its use does not require any additional software installation. This is a significant advantage over other technologies (e.g. IPSec) from the perspective of flexibility, and mobility.

#### Forwarding voice and data over IPSec VPN-s

Today, legislation regulates the protection of information, including even that of unencrypted information, therefore keeping private or financial data safe is a task of critical importance. As a consequence of its structure, the Internet fails to provide sufficient protection for the packets that are transmitted over it. The goal of development efforts was to survey solutions with the help of which voice, video, and data can be forwarded in a secure manner.

The IPSec protocol – which the study analyses in detail – offers a solution for the secure transmission of IP-packets. The outcomes of this research can be utilised in the course of security challenges that are associated with the transmission of information related to triple-play.

#### Fixed line – mobile convergent products

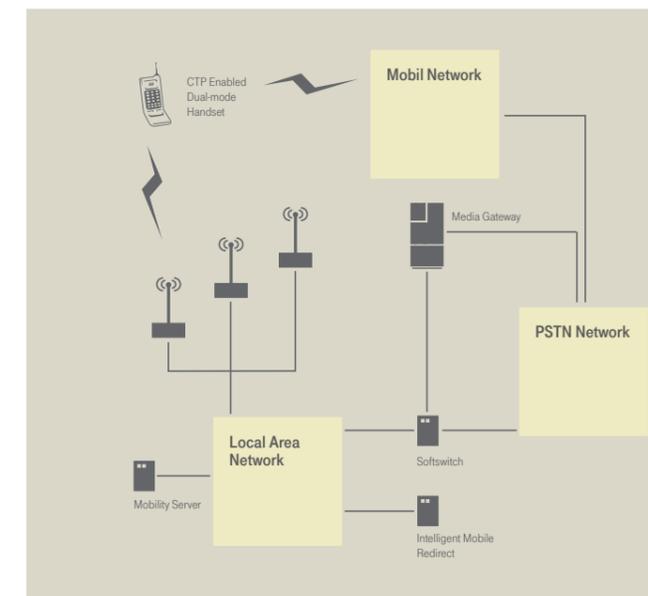
The demand related to the convergence of fixed line and mobile networks primarily arises on the side of the services that are provided to customers. Fixed-line terminal, and phone set manufacturers have come to recognise this, and also produce devices that boast features seen in mobile terminal devices (high definition colour display, integrated camera, polyphonic ring tones, etc.). Currently SMS, MMS, etc. are available over both networks as convergent services.

The objective of the project was to investigate the development stages of fixed-mobile convergent networks, to compare possible technical solutions, as well as to construct an operational specimen network. The research task aimed for the technical investigation of opportunities that can maintain Magyar Telekom's competitiveness in the medium-term, as well as the deployment of professional competency that is essential from the strategic perspective. A university, as well as an industry partner was involved in the research and development project for the sake of

formulating a comprehensive impression.

A study that introduces the possible technical solutions from fixed-mobile convergence was produced in the course of the project. The document introduces the various terminal devices, the voice-quality assurance related requirements, along with the convergent products that are already available.

One of the currently available specimen networks that is based on Bluetooth and intelligent call redirect functionality – which is being developed by our industry partner – was constructed as part of the R&D work. The following diagram shows the system-technology structure.



#### Optical systems

Learning about the physical factors that have an influence on the transmission quality of high-speed optical networks was set as the objective in the scope of this topic. In order to do so, the attenuation, as well as dispersion parameters of the DWDM backbone network were surveyed.

A computer application was developed to verify dispersion compensation. As a result of these calculations the modification of compensation element values was proposed for the DWDM backbone network, whose practical implementation were performed in part using existing spare components, and in part by means of exchanging things between one another. The success of calculations was partially proven by means of Q-factor measurements. Q-factor measurements were used to verify also that the measurement process is suitable for the proactive quality monitoring of high-speed DWDM networks, and for the optimising of physical level network settings, as well.

Results derived from calculations were verified by means of instrument measurements and sampling. Similar

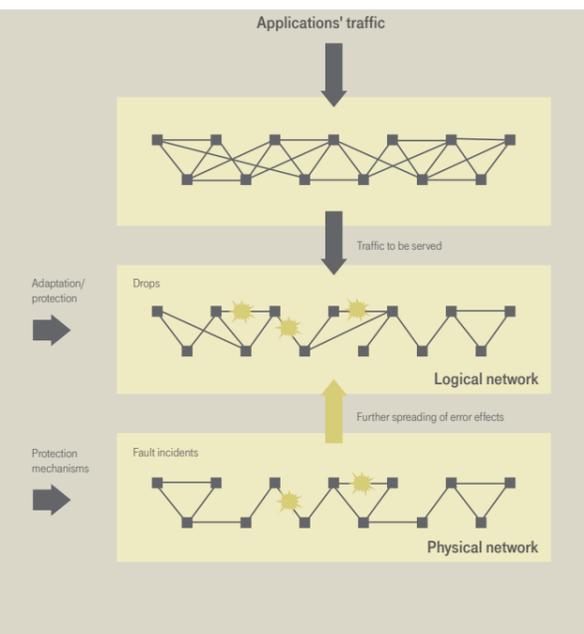
sample-based verification measurements were performed for determining the noise factor of optical amplifiers, and also for the operational wavelength monitoring of optical systems. The measurements, which were performed in limited numbers, showed a proper level of harmony with theoretic expectations, and are helpful for the proactive quality maintenance of optical networks.

#### Development of network design methods

In the course of developing design methods, we strive to make such design, and investigation methods available as a result of R&D activities, which can provide effective support for optimising Magyar Telekom's networks, both from the technical, and the financial perspective.

#### Elaboration of the reliability analysis methodology for T-Com's IP-network

The continuous increase of applications that are implemented over the IP-network, and the increase of traffic for services that require guaranteed quality is gradually raising the value of reliability, as well as



availability implications of IP-networks. The objective for the methodology development that was launched in 2005 was to elaborate models, indicators qualifying the network's reliability, as well as analysis processes, which can be put to effective use in analysing T-Com's operational, and planned IP-networks' traffic, and also reliability. The methodology that was elaborated makes it possible to quantify any potential insufficient resources, configuration or architecture related weaknesses in the network, and also what impact these have on the quality of services, in the interest of being able to deploy a network

that satisfies service provision requirements cheaper, as well as more efficiently than before.

In the course of developing the methodology, the reliability modelling and analysis of network structures built from several technological layers (IP, and the lower layers that provide services to it) was set as the objective, and during this the layer-focused managing of direct, as well as indirect impacts that have an influence on the network's functionality was given a defining role. In light of the fact that the different layers are built one upon the other, faults may have an impact on layers other than where they occur, even in higher network layers to which the given layer provides services. In case a malfunction occurs in a given network layer, and there are reactive protection mechanisms in place within the given layer (e.g. switching over to a protective route), these are activated in order to mitigate or eliminate the impact of the malfunction. In case there are adaptation mechanisms in the given layer (automated processes that react to changes in topology), then these are activated as well. Parallel to the activation of protection and/or adaptation mechanisms, the fault may, however, spread towards the higher level layers, where it can result in the losing of a network element. When the protection, and adaptation processes are completed, a new, and stable network configuration comes about, which remains in place until such time as when a repair event, or another malfunction incident once again alters the network's status. Using the methodology in the network state that comes about in this manner, it is possible to determine what kind of damage the network incurred because of the malfunction, as well as the extent to which it will subsequently be capable of meeting the quantity, and quality service requirements that are set for it. The method that was developed models the spreading of error incidents, the network's adaptation processes, as well as error impacts, thus making the detailed, quantitative analysis of traffic conducting possible even in the case of network errors. The implementation of definitive functional elements for the applicability of the methodology was achieved in the XPLANET design system, after which T-Com's planned IP-network was examined. Error impacts were detected in the course of this, along with their consequence on the network's configuration, the possibility to channel traffic demands, as well as the development of link loads, and we also determined the network's availability characteristics. The traffic, as well as reliability analyses that were produced with the help of the methodology serve as the basis for drafting our annual, and conceptual network development plans.

#### Enhancement of the IP-network's bottleneck-detection method

As the continuing of the research that was commenced in 2004, the objective was set to enhance the measurement methods, and analysis procedures with which we can make deductions concerning potential bottlenecked links in T-Com's IP-network, as well as its parameters that describe service quality, and the micro-structure of traffic. In the course of development efforts we considered the collection of traffic analysis information which can be put to use for the scaling of IP-network resources to be of critical importance. During the tests we were looking for measures with which congestion developing at links that are farther away from the measurement point can be detected by means of analysing the header data of packets that pass through a given interface.

One of the new indicators in the X-measure, which is the ratio of the mean-square deviation and expected value pertaining to the bandwidth of TCP processes. The underlying principle for this measure is that the bandwidth of processes fluctuates strongly over links that are not overloaded (scatter is great), while the speed of connections passing through a narrow link is more even, therefore the traffic links which pass through a bottlenecked link can be expected to have a low X-measure.

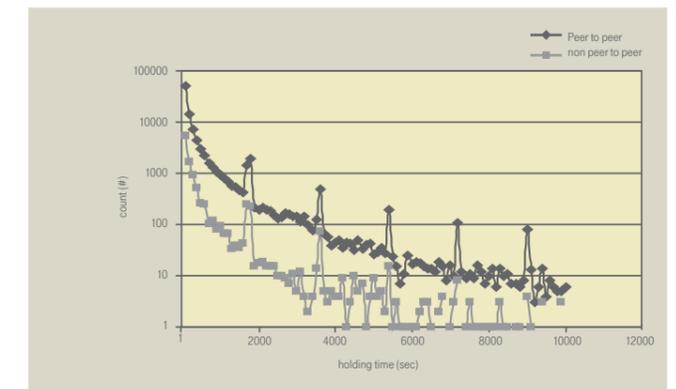
Lag coefficient is another measure. Bottlenecked links can also be located with its help. Lag coefficient shows the amount of lag experienced by flows incoming from a given direction compared to an ideal state over the course of their progress. A new flow-definition was also introduced for the definition of the measure, one which accelerates calculation.

The fourth central momentum of the packet receipt interval is also an interesting measure. We observed that in the case of bottlenecks packets follow one another densely because of the high level of link utilisation. For this reason the number of "short gaps between packets" is quite high in the measurement, which peaks the distribution density of receipt intervals. The measure showed positive values in the case of existing bottlenecks, otherwise its value was negative.

We also examined whether or not traffic over a bottlenecked link differs in its bursting characteristics from traffic over a link with normal load, moreover whether or not the random receipt model that can be applied in telephony is validated. We came to the conclusion that the burst nature of traffic remains when examined over several timescales, bursting, nevertheless, was not large scale on the measured links.

We attempted to identify peer-to-peer (P2P) traffic within data collected with the measurements using various

methods. We developed a heuristic procedure which is based on the characteristics of both P2P, and non-P2P traffic as they appear in measurements. Results showed that certain differences between P2P-traffic and other types of Internet use may be detected within user habits. An important result at the network design level is that the characteristics of aggregated P2P-traffic are essentially not different from the characteristics of non-P2P type Internet traffic. Our tests showed that a significant proportion of active users are running P2P applications as well. Similarly to traditional Internet traffic, P2P traffic also shows a slowly decaying distribution, both in the case of process size, and the holding time of processes. Holding times are shown in the following diagram.



We also looked at the examination of user satisfaction in connection to the research topic, in the course of which we attempted to discover the correlation of user satisfaction with the indicators that can be measured in the network. We ascertained the effectiveness – as a measure for indicating satisfaction – of the lag coefficient in the course of examining the different measures, as well as the packet loss ratio's suitability for use.

#### Transport network analysis and optimisation.

##### Utilisation of free capacities

The methodology development launched in 2005 had the purpose to develop such models, indicators and analytical procedures, with the use of which the reliability of the network can be judged and which can efficiently be used in the optimisation of transport networks. In the course of this activity we have attached great importance to the elaboration of methods enabling the benchmarking of the ideal and the actual network status, to the carrying out and evaluation of these comparisons and to the improvement of methods applicable for the controlling the consistency of data retrieved from network inventory.



### Application of optical cross-connects in the transport network

Regarding optical cross-connects, we have investigated the network planning principles of meshed networks, the characteristics of opaque and translucent networks, the network engineering aspects of purely optical networks and the physical limitations of homogeneous optical paths. In addition, we have reviewed the routing strategies in optical and hybrid (optical/electrical) layers, the system technical and technological background of OXC equipment. We have carried out the technical assessment of the equipment available at the present on the market, their technological implementations and a comparison of typical characteristics of their system technical set-up.

### Network design, traffic engineering and system technical planning methods of domestic Ethernet network

In the course of our R&D activity we have set as objective to generate an optimised tree-topology, the determination of the type of Ethernet switches and place of their installation, the implementation of the necessary links among them, or the connection of DSLAM, if they are

located elsewhere than the switch. We have investigated, if taking into account the available free fibres, there is a need to apply wavelength multiplexers somewhere, with regard to the distances and the eventually applicable wavelength multiplexers we have determined the type of the required optical interfaces, and in case of application of wavelength multiplexers, we have made a proposal where (to which existing system) they should be installed.

The result of the planning activity is a principal system technical drawing, which indicates all the points of demand (DSLAM-s), the Host, the Ethernet switch to be installed, the existing Ethernet switch, the optical section, the type of interface belonging to it, the length of the section, the copper cable section and the length of it, the microwave section and the length of it, the section and the length of section to be extended with wavelength multiplexer. The data generated by the program include the devices to be installed at the individual sites, or on the basis of the costs belonging to the individual devices the amount of the Capex required for the developments can also be estimated.

### Elaboration of planning methodology for new generation WDM transmission network

Similarly to other technologies, the WDM technology applied in the network of T-Com is undergoing a continuous evolution. Newer and newer devices appear, broadening the horizon of planning, therefore the planning methods, too, need to be renewed from time to time. Within the scope of this R&D task we have set the objective of short-time further development of the planning of new generation WDM transmission networks, along with the forwarding of STM-16, STM-64 and GbE traffic demands via the available free optical channels, or making of such free optical channels. In addition the work aimed at the creation of the definition for cable groups, with regard to their cost impacts, too. We have investigated the issue how WDM transport networks can be upgraded irrespectively from the time-horizon of planning, or how the uniformed (device independent) handling of wavelengths could be implemented, how the effectively usable wavelength (with transponder) can be taken into account, or creation of a planning method for card-level engineering of devices. The map on the last page shows the implementation of WDM backbone network as per status end of 2005.

### Application of EPON/GPON in the access network

The purpose of this task was to give a comprehensive review on the theoretical bases of access systems of the Ethernet-based passive optical networks (EPON) and Gigabit-based passive optical networks (GPON), to summarize the requirements set against these systems, the capabilities of the physical layer, the existing standards and the existing or planned implementations. In the frame of this work, we have reviewed the services of access networks, the service (and quality) requirements of access networks. In addition we have analysed the fixed line access architecture and technologies based on passive optical networks, and summarized the relevant standards and recommendations. Based on the standards and optical devices we have specified the requirements of the physical layer. We have tested the standardized elements of MPCP-s (Multi-Point Control Protocol) that provides multiple accesses. We have reviewed the systems that have been implemented so far and on the basis of the standards the possibilities of the development of Ethernet based service environment. As additional result of this R&D activity there have been tested those services, too, that can be implemented on EPON networks. At this place, a proposal has been made how the required service quality can be ensured with the introduction of an Ethernet-based service model. The interworking of the service model with the dynamic bandwidth control of the physical layer was also subject of the tests.

## R&D Consortia

A R&D consortium is a company form having no legal entity. It is based on voluntary assumption of obligation by its members and is set up exclusively with a dedicated professional objective. Magyar Telekom Group has recognized the substantial research potential of consortiums that can be exploited both professionally and financially. In the recent years we were successful in winning support in several consortium tenders, or there are ongoing projects where the research work is in initial phase yet. In the followings we report on some actual consortium activities performed in 2005.

### Adaptive media stream service architecture for the latest mobile telecommunications systems

On the R&D tender launched in 2004 by the Agency for Research Fund Management and Research Exploitation (KPI) support was granted to the consortium consisting of the members stated below:

- Inter-University Centre for Telecommunications and Informatics (ETIK),
- Telecommunications and Mediainformatics Department and Telecommunications Department of the Budapest University of Technology and Economics (BME),
- PKI Telecommunications Development Institute of Magyar Telekom Plc.,
- T-Mobile Hungary Telecommunication Company Ltd.,
- Ericsson Hungary Ltd.

The project has set the objective to develop - first of all for mobile environment - such a frame service architecture, with the help of which scalable and quality media stream (streaming audio and video) services and applications can be provided in a flexible manner, tailoring them to the actual customer needs and the changes in the status of the network.

In the frame of the work performed in the consortium a study has been made on virtual overlay network. The study discusses such issues, like the implementation possibilities of virtual overlay networks enabling media (streaming) content services, the service types of multimedia networks from the perspective of traffic engineering, the actual characteristics of the network to be tested, the considerations to be taken into account in creation of a theoretical network and costing model needed for network optimisation and the system plan of the software resolving the set network optimisation task. The other study made in the frame of the consortium work discusses the functional structure of fixed networks. It introduces the theoretical background of media stream transmission, the fixed and mobile reference networks,

as well as gives a basis for the system plan of software prototype to be implemented in the next phase and draws up the main steps of software planning.

The elaboration of the applied research tasks has commenced in the second phase of the consortium's work. It includes: the development of the virtual overlay network, the transmission of media streams through heterogeneous access networks, the assurance of service quality, the assurance of compatibility of dynamic client-server architecture, the clarification of data- and service security related issues. The work for setting up of the test lab and building of the experimental (test) system has begun; the first - JAVA language based - implementation of the client with basic functionalities is made ready and in parallel to that the UML software description will be finished soon.

#### **Establishment of Mobile Communications Research Developing and Innovation Centre - Mobil 2004**

The consortium consisting of leading telecommunications service providers (Magyar Telekom, T-Mobile, Pannon GSM), institutions of higher education (ELTE, BME, Pázmány Péter Catholic University) and industrial partners (Ericsson, Hewlett Packard, Sun Microsystems, Nokia, Siemens, MTA SZTAKI) won support in 2004 on the R&D tender launched in 2004 by the Agency for Research Fund Management and Research Exploitation (KPI).

The objective of the project is to establish a university scientific and technology innovation centre ranked among the world-wide leading such institutions, in the interest of creation of such a professional and regional 'centre of gravity' in the field of mobile communications that pursues outstanding research and development, as well as technology innovation activity, intensively co-operates with the players of the economic sphere, encourages the technological and economic development of the region and through it improves the competitiveness of the region and the country.

The individual sub-projects have closely specified the fields where the research activities should orientate to and accordingly the elaboration of the basic research tasks has begun. In 2005 the work performed in the consortium focused on the implementation of the test bed resting on NGN architecture. Magyar Telekom contributed to it with the specification of the laboratory IT and telecommunications infrastructure.

#### **MUPBED**

MUPBED (Multi-Partner European Test Beds for Research Networking) project is supported by the European Union and running for 3 years, closed its first year in 2005. The main purpose of the project is to test and introduce those



ASON/GMPLS based intelligent network technologies and solutions that help to build up the future's ultra-wide research networks and fundamentally ensure the competitiveness of the European research networks. During 2005 Magyar Telekom contributed to the activities of Workgroup dealing with the specification of the reference architecture of the European optical test bed network. Chapter 5 dealing with QoS related issues of Deliverable 1.2: „Revision of reference architecture according to the results of the project studies” was edited by Magyar Telekom PKI. The QoS aspects of the multi-layer networks, consisting of several administrative domains, were elaborated in a 150-page document that can be downloaded from the project's home page (<http://www.ist-mupbed.org>). While keeping in view the most relevant implementation requirements, the document draws up the way towards wide extension of QoS guarantee. We have published the results achieved in MUPBED project on several domestic and international conferences. In 2006 the work is continued and numerous simulation results will be validated on the actual MUPBED test network.

#### **GVOP 3.1.1**

The GVOP 3.1.1 (Services over Advanced optical Networks), shortly KEOPSZ project (see at: <http://opti.tmit.bme.hu/projects/keopsz/>) has been launched in 2005 with the consortium membership of Alcatel Hungary, the TMIT Department of BME and Magyar Telekom. The project is closely harmonised with PROMISE (Provisioning and monitoring of optical services) project, the European level research project of CELTIC (see at: <http://www.celtic-initiative.org>), that means common exploitation of results. The two-year long project analysis the advanced optical networks from the perspective of services with the primary objective to show the way from today's transport architectures towards the fully optical, service controlled intelligent optical networks. Among others, the project's objectives include the supporting of advanced high capacity services (Bandwidth on Demand, Virtual Private Networks, etc.), with assured end-to-end quality and reliability. Moreover, the scope of the project covers such aspects of optical networks, like: switching, control and management, reliability, network operations, QoS guarantees, end-user applications. Thus the activities include the testing of the existing network elements, controlling and management software, services and applications, and designing or developing of new ones according to need.

In the first year of the project - with the participation of Magyar Telekom - the definition of potential optical services and the specification of the most relevant requirements for systems providing the new generation of services have been carried out. Year 2006 is devoted to the identification of conditions required for the commercializing of optical services and to the determination of management, control and monitoring functions required by these services.

#### **GVOP 4.4.2**

The GVOP 4.4.2 (Construction of broadband network infrastructures by self-governments) project has been launched in 2005 with the purpose of providing broadband Internet access for small regions through this project of self-governments or self-government associations. Magyar Telekom is involved in several such associations, as project partner, namely, as operator of the broadband network infrastructure to be built. Accordingly, Magyar Telekom/PKI has formulated those network development guidelines, following which the network can be implemented economically. At the same time, there has been a choice of equipment given, too for the system technology corresponding the best to the needs and environmental conditions of a given settlement. We contributed to the compilation of the chapter giving a general description on the technical development contents of the application documentation to be submitted by the self-governments' association. We have elaborated those technical requirements that shall be met in order to ensure that the network to be built properly interoperate with the network of Magyar Telekom.

## Additional R&D activities

### Video transmission between 3G networks and IP-based systems

With the spreading of 3G mobile handsets, and the acceleration of convergence, users can be expected to intend using new services – such as video-phoning – not just in the direction of other handsets, but also towards IP-endpoints. This is why it is necessary for Magyar Telekom, and its subsidiaries to be familiar with the possibilities of implementing them.

The study that was prepared in this subject reviews the video, and audio technologies that are used, furthermore describes the system in which recoding the various formats is practical for a video-phone gateway in order to keep quality deterioration to a minimum. The study also describes the kinds of hardware capabilities that current 3G handsets possess, what formats they can support, and also the bandwidth requirement for these.

The study shows how a standard, 3G-based video telephony solution operates, along with the main architectural elements that are necessary for it. Finally, the study provides a detailed analysis of the gateway's IP side: what kinds of hardware, and software clients have become widespread, as well as what protocols can be used to reach them. The study includes the SIP, and RTP-protocols as well, furthermore the ways in which these can be utilised for video transmission arriving from mobile handsets, the problems that are associated with SIP-based VoIP technology – such as for example passing through firewalls and quality assurance – and also the solution possibilities for these.

### The elaboration of a mathematical statistics model for analysing the call habits of subscribers

In the course of elaborating the topic, a procedure, and methodology was formulated, allowing for the processing of a complete month's subscriber call volume at Magyar Telekom using an office PC.

The devised methodology ensures that statistics processing only utilises the relevant information, therefore customers' privacy rights are not infringed upon. The data processing methodology that was created, then revised in the course of elaborating the subject makes the statistics analysis of the impact various tariff packages have on traffic in different relations possible, along with the utilisation of such data in network management, as well as network design. The methodology that was developed was tested with the 203 call-data records generating in September 2005, analysing statistics correlations, especially with respect to the number of calls,

their average call duration, and the impact that rounding tariff packages have on subscriber call durations.

### Examining the possibility of implementing number portability in the Fixed SMS system:

Before the introduction of the number portability service, the number-fields serviced by the various telecommunications carriers were specified in a clear-cut manner, so the routing of fixed-line SMS messages was performed on the basis of analysing the called number. After the deployment of the number portability service, the number field no longer identifies the telecommunications carrier, therefore sending SMS to ported numbers proved unsuccessful.

In the course of elaborating this R&D topic, we examined what kinds of possibilities there are for implementing successful SMS-sending to ported numbers. The various fixed-line, and mobile telecommunications carriers connect to the fixed-line SMS-system's different interfaces. In the case of sending SMS to ported numbers, the selection of the correct carrier interface is the problem. We performed a detailed analysis of the benefits, and disadvantages the various solution possibilities that are available for selecting the correct carrier interface have. Of the solutions, we performed the examination of the most favourable one from more than just a theoretic perspective, actually completing its practical implementation as well. We resolved the regular updating of information that are stored in the number portability database in the fixed-line SMS system. It is on the basis of this "live", continuously updated database that we manage the routing of SMS-messages dispatched to fixed-line, as well as mobile relations.

### The examination of hardware, as well as software criteria for the mass dissemination of new services in the PSTN/ISDN network

The widespread dissemination of convenience services is one of the highlighted ways to halt or at least slow down the decline that can be seen in fixed-line access line numbers. Manufacturers scale TPV switches for using services as well, therefore before launching any campaign, the investigation of introduction possibility is indispensable in the interest of the necessary capacity enlargement. The objective of this subject was to create the technical foundations for the better utilisation of subscriber lines, and increasing revenue as a result. A significant part of supplementary services require software resources, and scaling issues related to such are a rather neglected area in telecommunications literature, in Hungary, and internationally alike. This gap is filled by the study we prepared, which provides a detailed analysis of the

software resource requirements that supplementary services set in telephony switches used within Magyar Telekom's network.

### Introducing the V5.2 interface in Magyar Telekom's network

One of the significant novelties in circuit-switched telecommunications is that subscriber units independent of manufacturer can be integrated with digital switches through the applying of the V5.2 signalling system, which is based on international standards. Our objective was to investigate the possibility to introduce the signalling system in Magyar Telekom's network. The study produced in the subject begins with a theoretic summary, after which we surveyed the hardware, as well as software requirements that are necessary for setting up the V5.2 interfaces of the various switches, and then we elaborated the database configurations that would ensure operations as expected. We analysed the possibility to integrate switch-independent subscriber unit data with the existing system, which is indispensable to perform efficient installation, fault clearance, testing, and disconnection, as well as for keeping a registry. The V5.2 interface measurement and testing method that we elaborated is discussed, this provides efficient assistance for operations staff in commissioning, as well as fault detection tasks, and we also provide useful information for the scaling of subscriber units that connect using the V5.2 signalling system.

### Leased-line service on DSLAM

The objective of this topic was to investigate the technical possibility of migration from MLLN to DSLAM-technology, especially with respect to quality related requirements, as well as redundancies, moreover to perform interoperability tests between DSLAM-ABLNET-MLLN networks. The results of the development efforts made in the scope of this topic show that the tested devices are suitable for offering a leased-line type service, and that the management of the devices is also possible to implement. The quantitative value for availability was demonstrated in the study using specific calculations.

### The examination of the possibility to employ new search procedures within the primary data collection system ('PAGY')

The objective of this topic was to investigate what kinds of new search procedures need to be developed, as well as introduced within the PAGY-system on account of number portability, and carrier selection. As a result of the investigations it was possible to establish – using no more than simple comparative methods – that the search method currently in use accelerated by

a magnitude when C programs were running instead of special scripts, and file access was moved to a local file system. Search criteria becoming independent of the program itself during automatic search mode can be mentioned as an additional benefit. This was made possible by moving SQL filtering criteria to a parameter file. The use of carrier selection, as well as other prefixes frequently resulted in sought records being impossible to find in the previous system, but we also managed to eliminate that issue with this solution.

### The implementation of close-to-natural man-machine speech connection within information systems

The objective of this project was to create a man-machine speech-connection within speech information systems (e.g. interactive speech response, automated information provision systems, call centres, voice portals, etc.), whose use fits into how people behave, and is therefore significantly more natural, and pleasant than the systems used now. Research carried out in this subject extended to asking and navigating using speech, the question clarification dialogue realised through conversation, as well as the area of replying with speech. The enhancement the reliability, as well as noise-insensitivity of command word based control was also performed with respect to speech recognition. The corpus-based speech synthesiser (for the weather voice portal, and prompt generator) is in the experimental stage. An 8-channel LBS voice-portal prototype was completed as part of experimental development efforts, and is currently undergoing testing. The multi-channel, VXML-based prototype for "WAP with Voice" was also completed, and is currently undergoing testing as well. The weather voice-portal is operating in an experimental form as a stand-alone voice-portal. We are going to attempt to implement this portal in the LBS-system, thereby establishing the possibility for position sensitive weather reporting. The practical application of the planned "prompt generator" is currently awaiting basic, as well as applied research results. Apart from testing, a further necessary action is to investigate the possibility for increasing the channel number to at least 30, and for integrating the experimental system into T-Mobile's network.

### The development of equipment to assist the voice communication of the hearing impaired with mobile handsets

The objective of this project was to take speech and generate information that can be displayed differently using a smart handset, which can entail true help for keeping contact between the hearing impaired and healthy people. According to our concept, an animated

“talking-head” would appear on the handset’s graphical display, and speech could be lip-read from this. A touch-screen that can be connected to the telephone, and which uses our sense of touch could be another possibility. A speech analysis module that works on a real-time basis is necessary for both of these ideas. As the first step, we created this speech analysis module, which is a program developed for the Symbian operating system that generates the melcepstrum feature vectors that are employed in the majority of automated recognition systems using incoming voice signals. Our proprietary audio-video database was also completed. We selected the optimal voice-image transformation. Employing key component analysis is the conceptual innovation in the procedure, researchers in Hungary have never employed this for similar purposes. Hearing impaired users correctly recognised the moving image generated from speech signals by lip-reading at the ratio verified in experiments. We plan to continue work with testing in the operational network.

#### Data-mining – the analysis of database querying algorithms

The widespread dissemination of database use, moreover the spreading of information society established the basis for a new area of research to evolve, namely data-mining. The extraction of hidden, heretofore unknown, and potentially usable information from large data sets is a fundamental objective. Data-mining is an iterative, as well as interactive process, where human intervention is required between the various steps. Therefore there is not a single totally automated data-mining system available today, there are, however, partial tasks which can be automated either in part, or completely. Mining frequent samples in transactional, as well as structured databases is the main area of the research being discussed. The three key directions for research are mining frequent element sets, frequent sequences, and frequent partial trees. In the course of the research carried



out in this subject, we worked out a test environment that is suitable for testing ItemsetCode, SM-Tree, PD-Tree data-mining algorithms, as well as their efficiency. We are going to continue our development efforts. We are going to develop a flexible data-mining engine and a standard graphical/console interface that supports the solution of specific applications. Research and development results that have been achieved are going to be adapted to specified user requirements.

#### The development of analyser to monitor applications that run on mobile devices

Based on current developers’ practices, applications that run on mobile devices are moved to the application environment after relatively short testing. The software tools that are available for verifying the operationally sound functioning of solutions integrated to different environments, and for analysing side-effects and cross-effects, and are indispensable developer tools in the majority of cases. The objective of the research was to develop monitoring software that can be used as a developer utility tool. In the course of the research carried out in the subject, we elaborated the study that summarises the criteria for monitoring applications that run on mobile devices, and we also formulated the software components that implement analyser functionality.

#### The elaboration of a C++ framework system to accelerate development work under Symbian

C++ development efforts under the Symbian operating system demands detailed, specialised work, therefore the lead-time for development is rather long, and development costs are quite high. In case tools that increase the efficiency of the development process are available for software developers, those applying the development will be exempt from all of these disadvantages. The purpose of the research was to establish a Class Library, as well as the development of mechanisms and tools that are based on using it, to set it in a developer’s environment, furthermore to create specimen systems which are suitable for introducing developers to using the framework system. In the course of research carried out in this subject, we prepared a study to summarise research results, and elaborated the C++ class library in program code format, furthermore we set the software tools that are based on employing the class library in a framework system. We formulated the specimen system that provides direct support to developers. We are going to continue researching this topic. Elaborating proposals for displaying the numerous services of the framework system that has been created on J2ME, as well as Windows CE-based systems is an additional objective for us.

#### The formulation of the e-Learning framework system

Fast technological development makes the development, and operation of a cutting edge corporate knowledge base, as well as electronic training and education system inevitable in the case of companies that are active in the IT industry. The spreading of smart-phones may constitute a good extension, because

- mobility may entail the fast mapping, and accessibility of corporate know-how,
- ergonomic thick-clients can be installed on smart-phones, and
- mobility, along with the e-Learning system may assist in the efficient utilisation of out-time(s) (travel, waiting, etc.).

The purpose of the research was to establish a system design and a framework system allowing the user to decide based on his/her will and current environment, whether he/she wants to access the software via mobile or web-based interface. The administration of the system can be done via a web-based application, and so an advanced web-based framework system can help in the preparation of the application. By selecting the cPEED3 framework system developed to assist the integration to T-Mobile’s Mobile Developer

Portal, we wish to ensure efficient development, high-level maintenance and the mobile-client integration. For the sake of permanent value and the portability between the hardware tools, the mobile client is built on the developed Simplan framework system. As a result of the research conducted in this area, we established the development concept and the system design for the framework system. Our development objective for the year 2006 is to develop in detail the framework system, based on the system design.

#### Establishing heterogeneous clusters

As a result of the continuous technological development, the performance of the personal computers and the bandwidth of the networks connecting them have significantly increased during the last recent years. As a result, the cluster systems built from computers interconnected in networks are from many aspects better solutions to resolve tasks with high computing requirements, than the conventional super-computers. Specific costs of such systems are considerably lower, they can more easily adapt to the changing requirements, they can be continuously extended, are scalable and the newest technologies can be incorporated almost immediately.

The purpose of the research was to establish a clustered architecture built on a given infrastructure, which would be able to combine the computing capacity of the available underutilized heterogeneous computers in order to ensure simultaneous processing of a task with high computing requirements.

As a result of the research conducted in this area we developed a study summarizing the system of requirements and the methodology of the analysis. As the next step of the research activity – on the basis of the developed system of requirements – in the year 2006 we will establish the Piramis model system.

#### Analysis of integration paradigms of software systems

With the increasing complexity of the software tools, the integration activities also play an increasingly important role. The objective of the research was to analyze the most frequently used technologies, the history of their development and the opportunities of interconnecting them. We also analyzed the exploration and assessment of the problems showing themselves on the various levels of the integration, as well as the development and demonstration of possible solutions. As a result of the conducted research activities, we prepared a study, in which we address in detail the potential problems that may show up in the course

of applying the available integration techniques. We introduced – in addition to the analysis of the technological background – the solutions and potential problems related to the web services. We put particular emphasis on the issues of security transaction operations, as well as certain integration considerations.

An additional objective of our research was to review and systematize the typical problems, to analyze the integration techniques/products implemented on the different available platforms, as well as to compare the applied techniques and software tools.

#### **Analysis of the J2EE Enterprise systems**

In the course of developing corporate-size information technology systems we face manifold and changing system of requirements. It is reasonable to summarize and resolve the typical tasks in form of a general framework system. The J2EE framework system uses a multi-layered and divided application model, and provides wide range of services to the users.

The objective of the research was to establish a model capable of analyzing and forecasting the efficiency of the J2EE Enterprise systems, to develop an evaluation methodology to assess the efficiency, to determine the dominant factors from the aspect of throughput, resource utilization and response time, as well as to develop an assessment technique built on the use of these factors. As a result of the research, we built a model determining the framework of completing the analyses and determined the measurement points and procedures. We recorded all these results in form of a study and a demonstration system. In order to systematize the test results and the conclusions we established a test environment.

#### **Establishing a framework system to develop intelligent mobile controllers**

The objective of our research activity was to develop a model application for the GPRS data connection system between the VMX-based passenger information system and the dispatcher centre introduced and applied by the Budapest Public Transportation Company.

As a result of the research we established a model system, taking into consideration the system of conditions provided by the user. The operable system was completed and we introduced its live operation. The objective of the demonstration was to integrate into an operable system the technical options, on the basis of which both the potential users and service providers would become able to overview the factors determining their strategic plans concerning vehicle monitoring and traffic management.

#### **Meta-modelling software technology to develop telemonitoring systems**

In the development of the software technology we are facing a clearly increasing level of the linguistic abstraction. A similar abstraction level can be observed in the case of visual modelling languages appearing as an accompanying phenomenon of the object-oriented paradigm; these languages form a kind of an individual programming language within the frame of the Model-Driven Architecture (MDA). According to the vision of MDA, the developers should build and specify in detail a platform-independent model, mainly using the Unified Modelling Language (UML) graphic modelling language. From the platform-independent model, the model translators automatically create a platform-specific model by adding the information related to the current target platform, which can be run on the given platform. The objective of our research is to establish a meta-modelling technique, which defines the coercive forces influencing the model, as well as the elements the models can contain, in a graphic model (meta-model). We summarized the achieved research and development results in a research concept and a system design. We found that model transformation plays a basic role in the model-based development. It seems actual and rational to create visual model transformation tools in order to ensure faster development, the formalism of which is closer to the standard and well-known UML modelling language and combines the advantages of graph rewriting and meta-modelling. Our additional development objective is to establish the MDA framework system on the basis of the specification.

#### **Analysis of the mobile running environment**

Functions of today's mobile devices are implemented in various software running environments (Windows, Symbian, NOKIA). Applications downloaded to the mobile devices operate with different efficiency in the different running environments, so the question seems valid, i.e. what is the best environment for the various applications to download to. The purpose of the research was on the one hand to analyze the JVM profiles, the MS/CLR, as well as the conditions of selecting the optimal platform, and on the other hand, to prepare a comparative analysis regarding the selection of the running environments. As a result of the research, the analysis methodology for the Mobile running environments has been established in form of a study. This study contains a comparative analysis of the performance of the running environments Symbian, J2ME and Windows CE, the analysis of the opportunities for optimization and the program code representing the results of the research.

#### **Analysis of the Parlay-based server and client solutions**

The purpose of our research activity was to analyze and systematize the standards of the Parlay-based solutions, to analyze the related compatibility and efficiency issues, to develop methodological recommendations, as well as to formulate policies regarding the development of (visual) tools and solution types.

As a result of the research, we prepared a study summarizing the experiences and the results, and containing the conceptual set of requirements of the research work.

#### **Preparation of design templates for SOA systems**

The development of today's web applications has been gradually transiting toward implementations based on the loosely connected components (SOA – Service Oriented Architecture). As a state-of-the-art technique, the XML web services system can be considered, which ensures a flexible way for the scalability of the applications. The objective of the research was to analyze, how the selection of the services and the development of the design samples can be made more efficient by introducing semantic metadata. We wished to follow the objective, i.e. the object orientation-based software development concept should today be replaced with a standard development technique incorporating loosely connected, component-based, asynchronous units with changing redundancy and performance, available as services.

As a result of our research activity, we reviewed in form of a study the service-oriented architectures and the XML web services and analyzed to composition of the SOA design templates and the business processes. We also addressed the issues of the implementation, with particular emphasis on the web services implemented on mobile devices. We assessed the implementation opportunities regarding the communication of the gateway and client applications, and we developed design templates for the topics analyzed.

#### **The implementation opportunities of establishing a protected data connection between the networks of T-Mobile and BME**

The objective of the research was to explore the opportunities of establishing a protected connection between the BME University Information Technology Services Centre (Egyetemi Informatikai Szolgáltató Központ) (operator of the information technology backbone network of the Budapest Technical University) and the premises of T-Mobile. During our work we surveyed the requirements and needs of the potential participants on behalf of the Technical

University and of T-Mobile. We analyzed the implementation options for the framework system (security, technological, software system technology and system monitoring issues) and the possibility to separate the individual projects. We recorded the achieved results of the analysis in a study.

The study addresses in detail the security, monitoring, scalability and quality assurance issues of the planned data connection. It analyzes the structure of the backbone network and feeder network of the Budapest Technical University, then it reviews the potential interconnection opportunities of the BME and T-Mobile networks.

#### **Virtual loop (traffic congestion monitoring), video processing**

The objective of the research activity was to develop an automated video signal processing algorithm and application, which would provide quantitative results on the intensity of the monitored vehicle traffic. We developed an application, which is continuously capable of determining the number and average speed of the passing vehicles in an "idealistic" environment, with good visibility conditions. On the preliminary selected video records, the algorithm reached about 90 percent accuracy in determining the number of vehicles. The development will continue in the year 2006. Our goal will be to further improve the algorithm, to increase its accuracy and to optimize it for other weather conditions as well.

#### **Embedded systems VoIP service**

The performance of the embedded systems differs according to the functions to be implemented. The limited capacity of the onboard controllers as target hardware installed on the mass transport vehicles, ensuring the vehicle monitoring and the communication with the dispatcher centre requires an optimal implementation of the VoIP function to be integrated. The goal of the research is to launch algorithmic developments and to establish software solutions, which can be adapted to the available bandwidth.

In the course of addressing the topic we analyzed the opportunities of transferring voice data between the mobile devices via the GPRS network, the opportunities presented by the VoIP, their advantages and disadvantages, we introduced the standard lines of the topic, the characteristics of the real-time protocols and the opportunities of data compression. During the implementation we addressed the main problems showing up in the given hardware environment, such as the issues of bandwidth and compression. We also developed a model application operating in operational environment.

The objective of the further research will be the analysis of the opportunities presented by the 3G networks for the given task.

#### Online distribution of meteorological information

The objective of the research activity was to implement a pilot system capable of distributing online meteorological information of Hungary and Europe.

We completed the feasibility study for the online content provision; we paid particular attention to the availability, quality and usefulness of the information – for Hungary and Europe. The study completed in this topic summarized the information sources and analyzes the type and resolution of the available satellite images for uninterrupted, 24-hour operation. Our further research objective is to build a pilot system operable also in the information technology environment of T-Mobile, to populate it with test data and to carry out analyses.

#### Consumer-focused complex monitoring systems

The goal of our research activity was to explore the fields of application of wireless data transmission technologies and mobile communication in the food safety infocommunication systems, in form of a summary study. The legal background of the EU's and domestic food safety and food monitoring stipulates the establishment and operation of monitoring systems, but – due to the lack of strict control – it is today an isolated and initial activity. The comprehensive food safety database to be created encompasses the entire product field; therefore an infrastructure capable of forwarding and processing rather large quantities of data has to be built. As a result of our work, we've come to the conclusion that we shall recommend establishing a food producer and three different consumer query levels.

Achievements of the infocommunication development can quickly and widely be utilized in the information provision to the consumers. With the expected strict control of the legal provisions, the interest toward the established monitoring system will dramatically increase, which would generate significant data traffic increase.

Additional product fields and high numbers of users must be considered for the food safety infocommunication developments, and the information provision for the consumers must also be implemented in foreign languages as well.

Our plan includes the detailed definition and implementation of the concrete development tasks related to mobile communication, as specified in the study.

#### Authorization broker

A high level of licence-dependent content provision can be observed in the mobile and Internet user environment, used by a very high number of users. The Authorization broker allows the user to establish contacts with many service providers, while using only one (or a few) user IDs and authentication procedures.

The objective of the research activity was to develop an economically valid solution, in which one or a few identification and authentication service providers (authorization brokers) contract with each service provider and each user.

As a result of our research we completed a study, in which we summarized the most important information and knowledge required to establish the authorization broker role. Our additional goal related to the research is to create a system design serving as basis for the implementation.

#### Development of an ontology-based “professional helpdesk”

In the world of information technology, ontology has become a “trendy” concept, together with the semantic web initiative. The research project – while accepting the necessity, usefulness and usability of ontology from the start – searched the answer to the questions of how the ontology can be built, used and maintained in case of different purposes of use.

In the course of our research we reviewed the methodology of ontology building, reviewed the currently existing ontology models, their advantages and disadvantages, and we also analyzed their adaptability to the requirements of the Hungarian Unified Ontology. In the following step of the research we intend to compare the ontology-based document classification and content management with folksonomy-based document classification and content management.

#### Analysis of the product diffusion in the telecommunications connection network

The primary result of the project was the implementation of a software tool collecting many kinds of algorithms useful in the network research into a unified and efficient frame. For the application we implemented modules capable of graphically visualize networks, entire partial graph search and group structure analysis.

From these we shall specifically mention as the most important novelty, the graph algorithm capable of exploring the group structure of very large networks. The algorithm efficiently utilizes the clusters of the existing networks. It is mainly recommended to analyze data sets with low sampling error ratio, but we have achieved promising results on artificially generated networks, as well.

#### Establishment of a model for collaborative contents recommending and filtering tool for scientific and informative contents

A recommending system means the applications trying to make analyses on the basis of the individual profile of the user, and to specifically recommend sites/contents that will supposedly raise the interest of the given individual. Currently, the recommending system play an already important role in the orientation on the Internet, and it is expected that with the introduction of the mobile Internet they will also become available on the mobile devices. The objective of the research was to give an overview on the collaborative filtering techniques, to assess their strengths and weaknesses, and to make a recommendation regarding the community filtering functions of the website of Mindentudás Egyeteme (the ENCOMPASS). The result of our research activity is a study on the available forms of recommending systems and the community filtering techniques, as well as their sociologic and algorithmic bases. This way, the research serves as a ground for the research “Establishment of a Community Communication and Publication System model”

#### Map of competences

The map of competences is a knowledge management tool belonging to the complex corporate management HR tools, but it is partially built on other types of databases and partially on the logic of shared knowledge sources. In addition, it is also a tool facilitating organizational knowledge sharing and information flow, and can be integrated with internal communication tools, such as the instant messaging system, or other internal databases, such as the phone book of the organization. At the same time, its maintenance is simpler than that of the databases managed centrally or by several individuals. The map of competences we developed is equally and simultaneously capable of mapping organizational knowledge and tasks and to create a database providing different information for the managerial and subordinate levels, quasi screening the organization. In the course of our research we developed the methodology of this knowledge



scope of Hungarian-language popular information content provision services and the scope of the community portals. After reviewing the Internet-based Hungarian and foreign informative content provision services we deemed necessary to analyze in detail the potential system components used in a scientific information provision service with focus on the community, so in the second phase we completed a comparative analysis of these elements. In the last phase of the project – based on the above scientific results and practical experience – we prepared a functional specification of a community communication and content publication system built on the ENCOMPASS (“Mindentudás Egyeteme”) portal, mainly optimized for the popular scientific information context.

#### Research of economic and city-planning problems of the community services through the example of the WiFi HotSpot distribution

In the course of spatial distribution of the WiFi HotSpots allowing wireless Internet access in large cities the cultural space determining the use must be taken into consideration. The use of public WiFi is concentrated around coffeehouses, hotels, parks, restaurants and gardens. The objective of the research was to make a recommendation for the wireless Internet usage patterns, and the consequential access point distribution, based on the comparison of the physical and cultural space

of Budapest. An additional objective was to determine, if there is a winning strategy for the community WiFi service from city-planning and economic aspects, and if yes, then what is the optimal access point layout within the city that would result in a successful service. The related documentation contains the comparison of the different channels of going to the market and the definition of the common denomination of the cultural, physical and economic space.

#### Analysis of media and Internet consumer segments

There are measurement techniques for the media consumption/content consumption habits, and such surveys are carried out in Hungary on regular basis. On the other hand, currently there isn't a conclusive research method regarding how these surveys could be used to predict telecommunications habits, i.e. to segment the customers of Magyar Telekom. In the course of the research we've come to the conclusion that the segmentation based on the media consumption could play an important role in developing strategies for the broadening of the Internet market. Media consumption habits of the people, especially the cultural closeness of their media consumption to the commercial media contents basically determine how they use the infocommunication technologies.

In the research we distinguished five media consumption-based segments with the help of a clustering procedure performed on a database. After this, we determined the location of these segments in a space showing willingness to technical innovation – such as establishing an Internet connection – and we also positioned the segments according to the possession of fixed and mobile telephone, as well as according to the income status.

## 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 face with in 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 2005. R&D activities provided a basis for the introduction in the last year of WiMax based, EasyNet, VoKTV, 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 2005 we have elaborated 26 technical specifications or 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 2005 in this respect an outstanding task was to elaborate - altogether 17 - 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.

In this scope, we have tested - among others - new generation ADSL DSLAM and subscriber equipment, equipment of IP network, WiMax and WiFi systems and also started the testing of devices needed for triple-play services. All in all during 2005 we carried out qualification of 318 devices and three platforms. 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

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 or international relations - to the various forms of direct exchange of information and experience. We maintain close co-operative relations with universities and research institutions. Co-operations of industrial partners with research places of universities have been existing already for decades, but such collaboration forms have become more intensive in the recent years. Recognizing it, we have established closed relations with

the high educational institutions and are involved in their scientific research activities. Similarly, it is important for us to get familiar with the development activities of our vendors, as well, so that to be able to utilise the coming new products in our planning work. In the interest of gathering foreign experience we take role with growing activity in the work of international standardisation bodies. Accession to the European Union has opened new horizons for Magyar Telekom, too, to intensify its international co-operations and join and participate in various programs, aiming at the realization with international efforts of different R&D tasks and gaining experience of other countries. Utilising the funds won via applications submitted either alone or in collaboration with manufacturers, research institutions or universities, we can implement R&D programs promoting business growth. We introduce the various forms of such professional co-operation and our achievements in the following three sub-chapters. First we report on our domestic co-operations, secondly on our international relations and in the third part on the role of events organised by ourselves.

#### Domestic co-operations

##### Educational institutions

Regarding the educational institutions we have been maintaining - already for several decades - the closest relations with the Budapest University of Technology and Economics (BME). The co-operation brings advantages for both parties, once these relations form a basis for us for recruitment of young professionals. Secondly, these relations are important also because the University is actively participating - via the orders we grant to it - in network and product development related R&D themes. We are sponsoring several scientific-professional events organised by BME, which are the forums for exchange of experience continuously. On the other hand, the lecturers and researchers of the University take regularly part in great number in our traditional PKI Scientific Days, organised in autumn, or in our special workshops, which are organised usually in spring. Besides BME, we have been maintaining traditionally good relations for several years with the Kandó Kálmán Faculty of Electrical Engineering and the Neumann János Faculty of Informatics of Budapest Polytechnic (BMF), mainly in the form of delivery professional lectures and exchanging mutually our development results. Since the foundation of Széchenyi István University of Győr, we have been participating in the teaching of telecommunications related subjects. In addition, the personal and professional contacts are often needed also in connection with different labour activities taking place in the University

or in the Centralised Technical Support Centre (RTK) Győr. With Corvinus University of Budapest (recently: Budapest University of Economic Sciences and Public Administration) we have signed a long term co-operation agreement in 2005, which has the objective to strengthen the inter-institutional relations in the field of theoretical and educational activities and practical application of stock of knowledge.

We give diploma themes to graduating students of the Janus Pannonius University of Pécs, the University of Miskolc, the Pázmány Péter Catholic University and the Gábor Dénes College. While working on their theses, the students become acquainted with our development activities and in many cases they are actively participating in them.

In addition to the mentioned forms of co-operation we regularly evaluate diploma theses and take part in the work of the State Examination Committee.

#### Inter-University Centre for Telecommunications and Informatics (ETIK)

ETIK was established in 1998 with the purpose to strengthen relations between manufacturers, service providers and BME. The results are utilised by the consortium members. Magyar Telekom, who is one of the founding members of the Centre, plays a key role both in the setting of the targets and in the assessment, evaluation of the fulfilment of the tasks. The Co-operative Research Centres Program (KKK) of the Ministry of Education supports the Centre with grants that along with the contributions paid by the industrial members enabled launching of new project tasks. In 2005 we worked jointly in the subject fields of multimedia, signalling protocols of third generation mobile networks, possible implementation of fixed-mobile convergent services, system technology of WiMax networks and security services.

#### Scientific organisations

We have oldest traditional relations with the Scientific Association for Infocommunications Hungary (HTE). Magyar Telekom is represented by two members, delegated from PKI, in the Board, and we take part in the work of almost all sections. We are involved in the organising committees of various events, as well, where we can 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 participating in the National Innovation Award Competition and till today it has been awarded three times with Special Innovation Prize for its four submitted competition papers. The authors of these studies are mostly PKI experts. To the 14th National

Innovation Award Competition (2005) Magyar Telekom - jointly with T-Kábel - has submitted a study paper titled: "Introduction of IP-based telephony service (Kábeltel) at T-Kábel", which has been recognised by the judgement committee with a certificate of merit. The successful participation demonstrates that Magyar Telekom can appear from year to year with remarkable innovation results. Magyar Telekom is a founding member of the Hungarian Standards Institution (MSZT). The representative of our company is an elected member of the Standardisation Council, the management organ of MSZT. Our specialists lead several technical committees, prepare national standards and actively contribute to the work performed in the frame of national, program and technical committees. Through MSZT we take part in the activity of the European Committee for Electrotechnical Standardization (CENELEC).

#### International relations

The European Telecommunications Standards Institute (ETSI) is one of the official standardisation bodies of the European Union. Magyar Telekom has a full membership in the organisation. The standards and specifications of ETSI - that we utilise in our network and product development projects - form the basis of the international interworking of telecommunications networks. Hungary is interested especially in two professional fields, namely in the protocols of next generation networks and in the standardisation and introduction of DSL technologies. PKI experts have been regularly taking part in the past in the meetings of TIPHON (Telecommunications and Internet Protocol Harmonization over Networks) and SPAN (Services and Protocols for Advanced Networks) professional committees of ETSI. To enhance work efficiency these two professional committees have been merged into TISPAN.

In 2005 the priority one task of ETSI TISPAN was to complete the first release of IMS based NGN architecture. Though this target could not be achieved entirely, nevertheless the first versions of most of the standards have been closed. Magyar Telekom represents itself within TISPAN in two Working Groups, namely in WG No. 2 (Architecture) and in WG No. 4 (Numbering and Routing). Convergence of traditional telecommunications technologies and Internet communication attaches special importance to this scope of issues and to our participation in the meetings, where we can acquire such information, in lack of which it is very difficult to develop competitive services meeting the European standards. In the last year broadband services have been delivered to further hundred thousand households. Currently we are studying the applicability of DSL technologies, the

possibilities of their upgrading, in connection of which the standardisation work is going on in TM6 of ETSI and in SG15 Study Group of ITU-T. Our participation in standardisation 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.

The standards elaborated by ITU-T and ITU-R, the telecommunications and radio branches of International Telecommunications Union (ITU) ensure the world-wide compatibility of telecommunications networks and services. Similarly to ETSI, the recommendations and interim working documents of ITU provide important input information for Magyar Telekom for the implementation of its development tasks.

We participate in two international research associations, namely in the European Institute for Research and Strategic Studies in Telecommunications (EURESCOM) and in the DSL Forum. While EURESCOM sets up special workgroups to resolve standing or topical problems, DSL Forum focuses always on a particular problem. Magyar Telekom Plc. has been a shareholder member of EURESCOM since the establishment of the latter.

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 many promising results to shareholders. Nevertheless, keeping in view the business interests, the transformation of EURESCOM from an organisation cooperating based on membership into a modern project managing and telecom advisory company, has begun.

In 2005 we were interested in the following projects or studies:

- P1401 OSIAN – Digital Home – development of multimedia services (project),
- P1448 Opportunities offered by carrier grade multipoint services (study),
- P1552 Open sources for next generation OSS-issues and challenge (study),
- P1557 Fixed-mobile convergence (study),
- P1559 VoIP security (study).

DSL Forum, as an international consortium, brings together 200 members, including leading service providers, equipment manufacturers and other partners, e.g. non-profit organisations. The objective of this international Forum is to exploit the full broadband potential offering reliable and easy-to-use access devices at a price which allows satisfaction of mass demands. At present Magyar Telekom has a "Principal Member" status in the Forum. In 2005 we participated in the work

of several workgroups and we have utilised the results in the upgrading of our DSL and triple-play network system technologies, in the system integration of Ethernet DSLAM-s and in the identification, specification of the capabilities and features of standardized DSL subscriber terminal equipment.

Development co-operation within Deutsche Telekom Group plays an important role in the harmonisation of development and O&M projects of Magyar Telekom, Croatian Telekom, Slovak Telekom, Deutsche Telekom and MakTel. The primary goal is to ensure infrastructure compatibility based on ETSI and ITU Recommendations. This includes implementation of joint development projects, or on DT Group-level cost-optimised networks for instance creating joint terminal equipment portfolio and uniformed ADSL and IP platform, and preparation the introduction of new technologies (e.g. WiMax), strategic harmonisation of next generation network concepts. The development themes launched with common efforts offer the opportunity of exploitation of Group-level synergies, while pursuing efficient financial and human resource management and involving common contractual partners.

#### The role of events in our relations

To present our achievements, to exchange experience and strengthen inter-personal relations traditionally we organise two major events in every year. One of them is organised in spring, while the other is held traditionally around 20-22 November at the date of the foundation of PKI Telecommunications Development Institute. One of the outstanding events of 2005 was the Fourth Hungarian WDM Workshop that was organised with the effective contribution of the Scientific Association for Infocommunications (HTE) and two faculties of the Budapest University of Technology and Economics (BME). The event took place in the Headquarters of Magyar Telekom on 1 March 2005. The thematic of the conference was not limited to WDM technology only, but it dealt also with the telecommunications-related achievements of IP-optical integration and photonics that will determine the new era of optical telecommunications. The conference event of PKI Scientific Days that we held on 22-23 November 2005 focused on the topic „Entertainment and gaming on the net". The program treated of the future of telecommunications and IT, the future expectations, while in the sections topical issues were discussed. Certain presentations introduced the possibilities of broadband network, or the new fixed line and wireless solutions. Others have touched upon such issues, like for instance communication diversity, the role of 'Mindentudás Egyeteme' in shaping of the society and sociological aspects of technical evolution.

# Key indicators of R&D activity



## Key indicators of R&D activity of Magyar Telekom Plc:

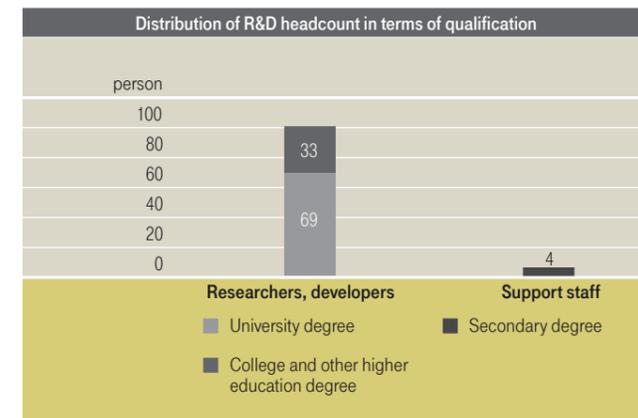
Within Magyar Telekom Plc. R&D activity is not performed in dedicated research places. The Company's most important organisational unit dealing with telecommunication research and development activity already for decades – and till 2004 exclusively – is PKI Telecommunications Development Institute. From the last year on activity of this kind has commenced – mainly in the field of media and communication sciences – at other organisations of Magyar Telekom, too.

### Headcount figures

Magyar Telekom Plc. has employed nearly the same number of employees in R&D project themes in 2004 and 2005. The relevant data are shown below:

Denomination	2004	2005
Headcount employed in R&D themes (person)	102	106
Full-time R&D headcount (person)	34	32

Magyar Telekom Plc. has a staff with outstanding professional skills and experience to perform the occurring technical development tasks. 89% of the colleagues working on R&D themes have qualification obtained in a higher education institution. Most of those employed in technical areas speak at least one foreign language. The diagram below shows the distribution of R&D staff by qualification.



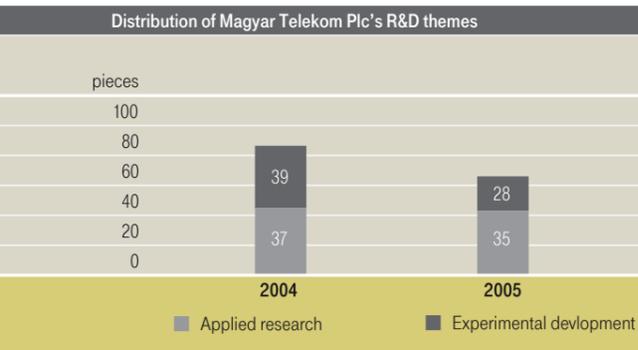
### R&D themes

As presented in the table below, Magyar Telekom Plc. has handled R&D themes in the following volume during 2004 and 2005.

As it can be seen from the table, compared to the previous year, the number of themes has slightly decreased in 2005, since in line with our R&D strategy and objectives we have launched more comprehensive, large-scale

Denomination	2004	2005
Number of R&D themes:	76	63
From the above successfully completed	76	63
From R&D themes: applied research	37	35
Experimental research	39	28

project. 85% of our research and development themes targeted telecommunications related, 15% of them media and communication sciences related subjects. All of the research themes have been successfully accomplished. The results of applied research and experimental development projects implemented with the involvement of our own internal resources, or external partners, are utilised within the Company.



No basic research activities are carried out by Magyar Telekom Plc. In 2004, from our technical development themes 49% belonged to the category of applied research. In 2005 even greater emphasis has been put to applied research activities (representing 56%) aiming at development of new procedures or methods. Magyar Telekom Plc. is actively participating in the work of domestic or international consortiums as well. From the Hungarian projects, we have been co-partners in two consortiums, where we have been collaborating – among others – with the experts of Budapest University of Technology and Economics (BME) and Eötvös Lorand University. Moreover, we have joined two other consortiums, where the actual research work will begin in 2006.

In the frame of international co-operations we have elaborated five EURESCOM themes and one consortium R&D theme (in MUPBED project), whereas the latter was financially supported by the EU.

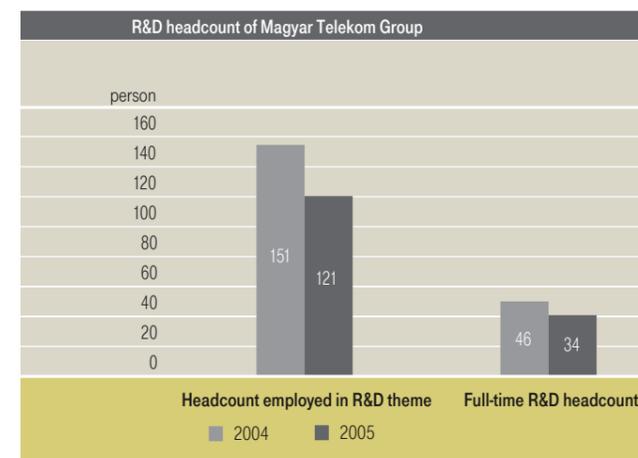


## Indicators of R&D activity of Magyar Telekom Group

Research and development activity has become more intensive at Magyar Telekom Group in the recent years. While in 2004 R&D has been performed from among the subsidiaries by T-Mobile, T-Kábel, Emitel and BCN Rendszerház, in 2005 – in addition to the mentioned ones – also EPT and T-Online have involved themselves into the implementation of research and development tasks. In the followings we introduce the main indicators of Group level research and development activities.

### Headcount figures

The following diagram shows the number of headcount engaged at Magyar Telekom Group level in research and development themes during 2004 and 2005.

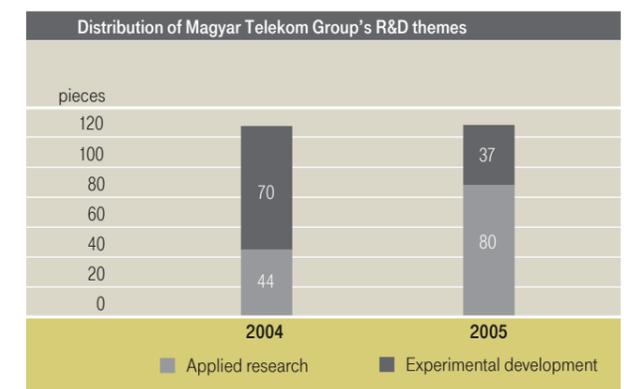


As it can be seen from the diagram, compared to the previous year (2004) the number of employees engaged in R&D themes has decreased nearly by 20%, because in the interest of more efficient utilisation of our internal resources and for obtaining knowledge we have entrusted external professional partners with the elaboration of certain themes. It resulted in that in 2005 the number of full-time R&D employees has reduced to 34. This change has affected mainly T-Mobile.

### R&D themes

88% of the 117 R&D themes pursued in 2005 have been successfully accomplished; the achieved results are utilised by Magyar Telekom Group. 68% of technical development themes belonged to the category of applied research and 32% to experimental development tasks. The table and block diagram below show the actual figures.

Denomination	2004	2005
Number of R&D themes:	114	117
From the above successfully completed	107	103
From R&D themes: applied research	44	80
Experimental research	70	37



# Outlook



All over the world the role players of the business life encounter serious challenges, since they have to meet new economic, social and cultural requirements. Ability for learning, adaptation, problem solving and innovation become very much important. There is a need of forming co-operations that build on mutual benefits and promote the learning and exploitation of the new scientific and technological results. In this respect, Magyar Telekom Group sets a good example by taking actively part in various national and international consortiums. This form of cooperation, on one hand, offers a new framework for specialization and division of labour, on the other hand, it opens the way for the creation of internationally recognized research places. We consider this form of cooperation as one of the important pillars of our future research and development activities. The economic globalisation processes have changed the nature of the research work and innovation activity, too. The importance of the state's participation in R&D has increased, first of all in fields being in a pre-competitive development phase. Similarly, education has a growing significance in laying down the fundamentals for corporate level innovation. In this situation, Magyar Telekom Group continues to support primarily those R&D project tasks that are close to their implementation. We strive for having an economic approach in the selection of research themes and in the assessment of researchers.

With this aim in view, we do support the exchange of information between the economic sector and the research places. Even today, Magyar Telekom Group maintains close relations with university and academic research institutions and – in the interest of the optimisation of the available human resources – intends to further strengthen these relations in the future. The developed transportation and information network infrastructure is essential for the economic growth. Magyar Telekom Group can contribute to the achievement of the set targets with advanced information network infrastructures and innovative services. Our R&D and innovation activities therefore need to be strengthened also in the field of telecommunication and IT services. Seeing the trend of technology evolution of the recent years, NGN still seems to be the real perspective for the telecommunication sector. In the field of the electronic communications (telecommunication, media technology, program- and content transmission, the interconnection of the networks, and the interworking of the different network- and service levels) the place of the so far used telecommunication and broadcasting networks will be occupied by one, IP-based integrated complex network, being capable to provide all of the recently used services (e.g. both voice or image transmission). NGN will likely renew or completely reshape the telecommunication

infrastructures, the competitive business models and user habits. This will be achieved by using new broadband access technologies, including 3G mobile communications. The wireless WiMax technology, that can over-bridge greater distances, can be a spreading technology too. These will radically change the today's localized or stationary Internet usage that may have an enormous impact on work and leisure time activities, on the social relations and on the time management and space usage of the citizens. The using of various portable/wearable end-user facilities (mobile telephone sets, PDA-s, music players, etc.) becomes more and more common, and there is a great choice from input/output devices, too. The miniaturization of the components partly rearranges the functions. The homes become "more intelligent" and the home entertainment centres appear more and more in them. The PC-s and their peripherals are redesigned and made suitable for new functions. The spreading IPv6 connects a number of devices to the communication network. From the above we can conclude that our most important development target is the consequent implementation of the NGN strategy, the continuous introduction of the coming new technologies and platforms, and on their basis, the introduction of new products and services.

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