Nation-Wide ICT Infrastructure Introduction and its Leverage for Overall Development

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EXECUTIVE SUMMARY

This paper describes ten years of efforts in introducing the state-of-the-art information and communication technologies (ICT) and development of ICT infrastructure on the national level. The aim of the project was to build Internet in Croatia and to foster its leverage in the broad range of activities of public interest in the society as a whole. The prime target group was academic and research community, as a vehicle for the overall development in the society.

Croatian Academic and Research Network (CARNet) had been started as a project in 1991, and, after five years, it was transformed into a government agency. A broad range of activities had been started, from building and maintaining private nation-wide communication and computer network to information services, user support, education, pilot projects and promotion.

The academic community has been treated not only as the main customer, but also as an active partner in developing and providing services.

CARNet has been fully funded by the state budget for ten years, without any participation of the commercial sector, domestic donations or international financial support.

Although CARNet is treated as Croatian success story, recognized inside and outside of the country, the question is whether the initial goals have been realistic and achievements sufficient, considering the low penetration of ICT into the Croatian society.

Likewise, budget cuts, continuous struggle for political recognition and authority, as well as fights with national telecommunication monopoly, have created an array of questions to be answered at the beginning of the second decade of this highly ambitious endeavour.

BACKGROUND

The late eighties of the 20th century had found Croatia as a part of the former Yugoslavia, with relatively poorly developed national telecommunication infrastructure and absolutely no academic network infrastructure. Due to the extremely difficult economic situation, the academic and scientific community had almost no access to the international scientific publications as well as scarce resources for traveling.

CARNet initiators perceived the Internet, and computer networks in general, as the possible way around this crucial obstacle to scientific and professional activity and development.

In 1990, Croatia had declared its independence from the former Yugoslavia, which triggered military intervention of the former Yugoslavian army and eventually led to a full-blown war.

CARNet initiators had three guiding principles regarding the future of the country. Firstly, the future Croatian independence was to depend significantly upon the strength of its economy. Secondly, the modern economy was to be information-based and future industry was to heavily depend on the scope, level, intensity and quality of application of information technology. Thirdly, much as in developed and progressive countries, implementation and deployment of new technologies were to be trusted to scientific community.

Those three principles led to a natural conclusion that Croatia needed a change agent. As a step forward, the national computer network was to be built in the academic community. The community was supposed to use it for its own education and work as well as to gain experience in pilot projects in various areas of human activities, and then to use the gained knowledge, skills and experience in helping industry and society as a whole to embrace and leverage the information technology for the development and strengthening.

This conclusion had been made by a small group of very young scientists already involved in computer networking development and deployment on the small scale. They prepared a simple proposal and approached Ministry of Science and Technology (MST), basically advocating establishment of national educational and scientific computer network. The Ministry accepted the proposal, the initial group and project director had been appointed and the seed money of $ 1 million was allocated. The project was dubbed "Croatian Academic and Research Network – CARNet."

In the first year of the operation, basic computer infrastructure and connectivity for about 40% of the community were established and were included in the Internet. From that point on, the project grew significantly, not only in the number of institutions to be connected, but also in introducing new activities and services like education, information services, pilot projects, etc.

This required technological and organizational changes in the project, as well as repositioning the whole project within a more operational institution than the Ministry was.

SETTING THE STAGE

In order to understand the environment in which the project CARNet has been launched and developed over the course of a decade, basic information on the political situation in Croatia, its market, telecommunication market and academic community seems to be required. In addition, the development in academic and research networking in Europe needs to be kept in mind as well.

Croatia

Croatia is a Mediterranean state located in the central Europe. It covers 57,000 square km. of land with 2,000 km. of land borders and 6,000 km. of coastline along the Adriatic Sea, its 1,185 islands being its special geographical beauty.

Croats had their own state already in 9th century. After that, they had been the constituent nation in various states from Austro-Hungarian Empire, Kingdom of Yugoslavia and, finally, Socialist Federative Republic of Yugoslavia (SFRY). SFRY had been constituted of six federal republics. By constitution, those republics had a right to decide on separating from SFRY. In 1990, in Slovenia and Croatia referendums were held and a vast majority voted for their respective independence. However, Croatia did not decide to separate from Yugoslavia immediately; it would have rather sought for more autonomy within SFRY, especially in independent self-deciding how to spend large sums of money it was to donate to less developed areas of Yugoslavia. It was only after Yugoslavia had launched into a military intervention in Croatia (September 15, 1991) that the Croatian parliament declared complete autonomy and separation from the rest of SFRY (October 8, 1991). European Union and United Nations soon recognized Croatia as a sovereign state during 1992. However, Croatia, who had to continue fighting off Yugoslavia, was pushed to defend its independence, and the war lasted until 1995.

During the war, one third of the territory was occupied and the population of barely 4.5 million had to accommodate over 700,000 displaced persons and refugees. As much as 30% of companies were destroyed either directly in the war operations or indirectly having had transportation routes or electricity supply cut off for several years.

Present-day population of Croatia is 4.3 million. About one fourth lives in the capital, Zagreb. GNP fell from 24.4 billion USD in 1990 to 11.86 billion USD in 1993, rising to 24.9 USD in 2000 (Source: Croatian Bureau of Statistics).

Market

Croatia is a parliamentary democracy with guaranteed private property and a market-oriented economy. However, 50 years of planned economy in Yugoslavia cannot be erased overnight, certainly not from the heads of people nor from the ways of doing business, which is offering very little readiness to integrate into global trends.

Previously, state-owned companies had been privatized, although it did not automatically bring changes in their product and services portfolios, internal organization or working practices. The Yugoslav market had been lost, and the buying power of domestic market had been tremendously weakened in the years of war.

Croatia inherited a monopoly in telecommunication market. By law and in effect, all telecommunication was in the hands of a single, state-owned company: Croatian Post and Telecommunications (HPT). Yugoslav Telecommunications were not in bad shape, though still far from developed, especially with regards to the services. During the war, Yugoslav army

had been advised to destroy telecommunication infrastructure. Although it was having a monopoly, HPT had heavily invested in development of infrastructure. In early 90s, they decided to rebuild a major infrastructure with new technology: fibre optical cables. Despite the war, Croatia soon had the whole national telecommunication infrastructure rebuilt and upgraded, and it was all optical.

In 1999, HPT had been divided into two companies: Croatian Post and Croatian Telecom ("Hrvatske telekomunikacije—HT" = «Croatian Telecommunications») with government declaring intention to have them privatized. Soon after, Deutsche Telecom became the strategic partner in HT, but the state kept controlling the significant package of stocks. In 2001, the government sold more stocks to Deustche Telecom, which made them the majority stockholder. The first deal was kept secret by both sides, and the public never got to know under what conditions their most profitable company and asset was sold. The situation was further mystified by the fact that government prolonged its monopoly period for an additional year (until December 31, 2003) as a part of the second deal. Neither was it ever clear whether Deutsche Telecom had bought the "holes in the ground," i.e., the infrastructure which could easily accept additional cables potentially from other providers, once the telecomm market in Croatia got fully de-monopolized. This is of particular importance as Croatia does not seem to have any other telecommunication infrastructure at present, not even for military, police or other public sectors of special interest. As a potential market entrant, Croatian electricity and power grid company did lay some fibres along their power lines but they have been far from ever representing a network, as it is far from any possibility of commercialization.

In contrast to the public expectations and political rhetoric, Deutsche Telecom did not enlarge investments in HT. Actually, they have been minimized. All investments seem to have even been stopped from the very first day. The prices for the services have remained very high despite some initial understanding of the possible reduction.

Academic and Research Community

The Croatian academic community consists of four universities: Rijeka, Osijek, Split and Zagreb. The universities are weak and formal unions, while real power lies in individual constituent Faculties (schools). Faculties are legal bodies with their own property, status and autonomy. There are 20+ public research institutes, but the majority of research is performed on the Faculties. The community counts some 12,000 staff and 100,000 students. The cooperation within the academic and research community is very weak.

The cooperation with commercial companies does exist, but it is far from the required level. This is partly the result of generally very low level of investments in research and development within the industry and partly due to enterprises' intentions to have their own research facilities not trusting the competence of academic and research community, in general.

As a consequence, the largest financing of the academic and research community comes from the state budget. Only 3% of the budget, or approximately US$200 million, is spent on all activities in the academic and research community each year.

In higher education, the law (1996 Act) allows privately owned educational institutions at all levels. However, the majority is still owned by the government and the higher education is free for all citizens of Croatia. Students do pay for textbooks, food and lodging. Still, those expenses are partly subsidized by the state budget. The overall quality of higher education is considered to be traditionally high, and proof can be found in the fact that Croatian diplomas

are readily recognized in most developed countries. The Croats who have graduated in Croatia easily get employed and prosper in the developed world. This is especially true for technical and natural sciences fields. However, there is a growing opinion that Croatian higher education needs redefining and restructuring in order to prepare students better for the information age and global economy. Unfortunately, the solution has to rely on slow formal processes, and it means mostly waiting for changes in legislation. There is no exploitation of possibilities for fast changes in spite of targeted developmental programs and projects, campaigns and experimental facilities.

Research is being financed by the budget through about 1,500 research projects with very low participation of industry. In addition, the tendering process run by Ministry of Science and Technology, typically re-launched every three to five years, does not specify practical problems to be solved but rather invites researchers to propose topics they find attractive to deal with.

There is almost a decade old program in place, aimed at rejuvenating the academic population by financing 1,000+ young scientists, in the period of up to 10 years, to achieve their master and doctoral degrees and attend the postdoctoral studies. Their salaries have been financed directly by the state budget through the Ministry of Science and Technology. They have been chosen among 10% of best graduates in their respective field and assigned to existing research projects, on the request of the project leaders.

Government Initiative

Croatian government consists of about 20 ministries that are to administer and divide the budget of approximately $6 billion. The budget is allocated predominantly to activities not projects. Although ministries are supposed to propose their budgets based on projects, once funds have been allocated there is virtually no project follow-up, and financing is based on activities rather than on results. In fact, in projects that last for several years, financing is provided for the next year, even if no results had been achieved in the previous years, largely due to the lack of monitoring.

Although officially CARNet project is a government initiative, it was actually an initiative of five engineers who were supported by a university professor, recently appointed deputy minister of science, at the beginning of the war. The project quickly (in the course of one year) generated large and visible results, and from that point on, it had been progressing using the so-called "avalanche" effect. Thus, despite overall lack of vision and guidance on the part of the government, and ministries of education, culture, and public health total lack of interest, the project was growing and remained present maintaining influence over a decade.

Academic and Research Networks

The idea of academic and research network was not invented in Croatia. It was spontaneously launched in late eighties in the developed countries of Europe and coordinated in the collective effort under the overall Framework of Research Programs of European Union.

EU recognized the importance of information technology and the need not to lag behind the development in the USA. Therefore, significant funds had been provided with the aim to develop new technologies and to build national but also pan-European academic and research computer network. In the later stage, funds had been provided to eligible countries

from the Central and Eastern Europe (CEE) for connectivity of their national networks to pan-European infrastructure.

Although specific and different, most of national academic and research networks (ARNet) were similar in their basic goals and operations. A typical ARNet was set to establish international connectivity and national backbone. Connectivity of individual institutions to the backbones was to be left to ambition and finances of individual institution. A minimum of services would then be provided just to support the basic activity, help desk, basic communication and information services, targeted research as well as information packages. Extensive information services, databases, large scale educational activities, pilot projects and promotion were not considered to be part of their tasks and duties. This view remained throughout the major part of 90s. As a contrast, the CARNet initiative, from the beginning, had a broad range of services in vision. Main differences between the typical academic and research network (ARNet) development scheme from a country in transition and Croatian are summarized in Bartolini (2000).

In addition, a typical ARNet would be strictly focused on academic community leaving the rest of population to commercial developments. Since, academic community was only the first phase of CARNet vision and, in many instances, a tool for overall national development, CARNet believed there is much more to just providing communication infrastructure.

CASE DESCRIPTION

As initially envisioned CARNet role was twofold: to provide infrastructure, services and support to the academic and research community (ARC) as well as to act as a change agent for the society as a whole. In order to fulfill the first role, CARNet initiated full range of activities of an ARNET (Bekic, 2000). The milestones are listed in Appendix 1. The second role could be fulfilled in two ways: by increasing the ICT and managerial competence of individuals (not only in academic community) and by CARNet's active involvement in implementation of ICT in national projects and systems.

Table 1. Comparison of CARNet and an Academic Network in a Country Transition

Typical ARNet of the country in transition	CARNet
Majority of efforts put in international connectivity	Majority of efforts put in high speed domestic backbone
International connectivity financed by EC and Open Society Institute	International connectivity financed by the state budget
A&RN maintains only backbone	Maintenance of the whole network
Support limited to connectivity problems	Support covers host administration, LAN designing, courses, promotion
From the beginning limited to academic community	Free access to everybody, pilot projects with the whole community
Most of the work is done by the A&RN itself	Outsourcing and project cooperation

Network Infrastructure

The technical concept of CARNet had been created at the end of 1991 (Pale, 1992). It was the time of the European Community's COSINE and lXl projects. TCP/IP protocol was considered too American and too old to be used in future European network infrastructure. X.25 & X.400 were foundations of European efforts (CISCO, 2002).

However, CARNet designers recognized that X.25 and X.400 products were still scarce and thus expensive. X.25 required specific interface in computers. Users needed more services from their computers and networks. It was recognized that TCP/IP was old, meaning reliable, that it was available for virtually every computer platform, that it would operate via RS-232 interface available in just any computer. It provided all services users needed e-mail, file transfer, network file systems, remote terminals and many others. It fully erased the difference between local and global networks from the user's and computer's point of view. The fact that it was completely license-free only sealed the first decision. Despite European trends and recommendations, CARNet was going to be an Internet network.

National public network infrastructures in Europe were built on PSDNs (Public Switched Digital Networks) mostly using X.25 infrastructure. Although such a network was available in Croatia (CROAPAK), it was scarce and expensive, and it only offered user speeds of up to 4,800 bps. CARNet was aiming at higher speeds: 9,600 bps. at least and 19.200 bps. preferably.

Thus, the second decision of the first phase was to build CARNet as a private network based on leased (copper) lines.

Phase One (1991-1994)

CARNet communication nodes were established in all university cities acting as local centers of a hierarchical, star-shaped network topology. Due to the lack of funds, speed of deployment and public telecommunication network being the frequent target of the wartime operations, planned redundant lines were never established. Thus, the established network topology was hierarchical with one major node (in Zagreb) and three regional nodes (in Rijeka, Osijek and Split). Despite that, the network operated with surprising reliability and availability. Within the first year of the project, the national backbone had been established and connected with the rest of Internet. In two years 60% and in three years 100% of academic and research institutions had been connected in CARNet.

Phase Two (1994-1996)

At that time (1994), the connecting speeds of 19,200 bps became insufficient, and, in some instances, bottlenecks were showing up. In addition, a single major node of the network (at Zagreb University Computing Centre – SRCE) was a continuing source of concern due to its vulnerability. As a single point of failure, it could bring the whole network down. It was clear that new backbone was required.

Most of European Academic and Research (but also other) networks had already switched to Internet technology and used 64 kbps and 2 Mbps leased digital lines, mostly via TDM (Time Division Multiplex) technology (Behringer, 1995).

It was difficult to obtain such resources in Croatia, and they were largely expensive. There was also one other concern: CARNet designers were fully aware that upgrade of the backbone would take between 18 months and two years. They did not want their new backbone to become obsolete again, before or at the time it becomes operational. It was

already clear that multimedia was going to be in demand, that voices and moving pictures were going to take up the major part of network traffic in the middle of 1996 when new backbone was going to be operational. Thus, the network backbone for the future, not for the current needs, needed to be established. Such a network had to be capable of transferring both, packet data and isochronous signals, like video and audio.

Fortunately, there was some good news. Firstly, new technology, called ATM (Asynchronous Transfer Mode) was emerging, aimed at unifying transfer of packet data (e-mail, file transfer, etc.) and of isochronous signals (audio, video, etc.) in one communication infrastructure. Secondly, Croatian telecommunication monopoly HT had been rebuilding public communication infrastructure using fibre-optical cables. They had plenty of raw bandwidth («dark fibre») and virtually no customers.

As a consequence, two strategic deals were made. The first one with HT, allowed CARNet, in the future, to use "dark fibre" (fibre optical cable between two CARNet nodes without any HT equipment in between) for a small and fixed charge. The second agreement, with CISCO, delivered CARNet the first available ATM equipment at a very favourable price which included education, replacements with next generation of equipment and other important benefits. In this way. CARNet, in the second phase, built a new broad band backbone at the speed of 155 Mbps with ATM technology that enabled audio and video conferencing throughout the country. The cost was 60% of the price that needed to be paid for the technology used on the backbones by other academic networks, offering speed of only 2 Mbps and no ability to do video conferencing.

In addition, the core of the backbone has been fully redesigned (Appendix 2). Instead of a single node, the core of CARNet backbone is now an "unfinished" cube (Appendix 3). Major academic and research institutions act as nodes, interconnected at 622 Mbps. Other, regional parts of national backbone are connected each to another node of the cube, at 155 Mbps. The core of the backbone is now fully redundant and reliable at the utmost.

Phase Three (1998-Present)

In the third phase, the connectivity of individual institutions (Appendix 4) to the backbone needed to be significantly upgraded. However, the dark side of telecommunication monopoly started to get prevalence. HT did not want to sell cheap copper-leased lines any more and allow CARNet to install xDSL modems thus effectively boosting up connectivity to 2Mbps or more. They forced CARNet to buy expensive 2 Mbps digital connections, but even with the contract signed, they did not deliver service. CARNet ended in an unacceptable situation: state of the art high-speed multimedia backbone, and obsolete connectivity of many members at speeds of 19,200 bps, sometimes even slower ones. Besides that, despite the signed contract, HT did not want to connect new institutions nor new locations of already connected institutions. The main reason was that HT perceived CARNet as a competition. Unable to attract other customers, HT wanted academic and research institutions as their customers at prices they could freely set.

Services

Initially, at the time when appropriate communication infrastructure on national scale was not available, the focus was on establishment of the backbone and on international lines. However, as the backbone deployment was well under way it became clear that it was not the only task, more needed to be done.

Connectivity Services

Deep in the foundations of the project was the goal to have as many institutions and individuals using the network as soon as possible.

Other national ARNETs, especially in developed countries, concentrated on establishment of backbones. They relied on the institution's motivation and financial resources to buy a connection from a telecommunications operator to the backbone. However, in Croatia, the situation was significantly different. Because of the weak and war-torn economy, academic and research institutions were almost exclusively financed from the budget. This financing was insufficient even for the basic operations. Other major unresolved problems in the academic community were outdated equipment, brain drain (towards the commercial sector and other countries), and the physical infrastructure (buildings) damaged. Besides, the Internet was a fairly unknown term in 1991, even in the academic community.

Therefore, CARNet couldn't count on their motivation, much less on their money. CARNet had to reach out much further than most other ARNETs, so its connectivity service included permanent communication line from an institution to the backbone. If an institution had multiple locations, multiple lines were needed. Services included purchasing and installing equipment for the institution's central node were communication (modem, router) and computing (UNIX server) equipment offering mail and web services to all students and staff of the institution. If the institution had no system administration capabilities, CARNet could offer such services (limited to the basic functionality of the central node), as well.

Individuals, who were members of the academic community, had rights and possibilities to access the Internet through modem pools distributed throughout the country paying only the minimal local communication cost.

In this way, CARNet provided "connectivity to the door" both to institutions and individuals, and it was free of charge for them, as end users. This initial infrastructure deployment was performed much in a centralized, planned fashion, almost without end-user involvement. The Internet and its services were simply given to them, regardless of whether they asked for it or not. However, this model proved to be very successful in bypassing the traditionally slow reaction and conservative approach of university managements. Pioneers and early adopters in community were embracing the "gift" and quickly spreading the "gospel". It was a kind of bottom-up approach with (extensive) external help.

Communication, Information and Data Services

As expected, a number of pioneers were found in the academic community who were to discover new communication services early on and to implement them for the sake of research, curiosity or prestige. However, CARNet quickly learned that services born in such spontaneous way would have the form, quality and lifespan according to the interests of individuals who started them, not according to the needs of those who would use them. Industry was fully unaware of the Internet and its (commercial) potential. The first commercial ISP started operation in 1996. Thus, the fundamental CARNet goal, to make the latest communication technologies and services available to every member of the community in the sustained way with guaranteed level of quality of service, cannot be fulfilled if it means letting "someone else" establish and run the service, i.e., hoping that someone would do it and do it in the proper way. Much more deliberation, planning and larger resources are required.

Therefore, a strategic decision had been made early on — that CARNet has a duty to take care that such services do exist and that they are available to everyone. CARNet should

also do its best to make the services free of charge to end-users (discussed in the "Finance" section) and to guarantee a level of quality of services.

It was felt that this approach will be chosen in other aspects of academic networking as well. As much as creators, financers and executors of this policy were convinced of the nobility of the goal itself and sure of the method to pursue it, they also believed that it would be wrong to try to provide those services from within the CARNet organization. Instead of increasing the size of the organization (potentially endlessly) and competing with (imperfect but innovative) services provided spontaneously by innovators and pioneers, it was decided to build on cooperation.

As a consequence, CARNet had encouraged individuals and institutions in the academic community to explore new services and to propose them for support by CARNet. CARNet was, then, jointly with them and potential users, to define the service, provide necessary equipment and money for sustained provision of the service. CARNet was also to promote the service and monitor its quality. In this way, the provider of the service was to get substantial supply of money for additional education of staff, salaries and other needs. They were also to get promotion of their work and thus visibility in domestic and international community. The equipment could be used for other academic purposes as well. Perhaps the most important benefit academic entities would get was the experience in providing a service and cooperation under "commercial" contract — something they did not have and very much needed in order to gain survivability in market economy.

If a partner for desired service could not be found in academic community, it would be sought in the commercial environment. It was believed that in such a way CARNet would serve as an active agent in modernizing Croatian economy, supporting development of the new services. CARNet's activities were to be focused on precise definition of service, tendering, financing, promotion and quality control.

In this way, CARNet had always established new **communication services** like news, list server, IRC, video conferencing, etc. The aim was to provide the academic community with new services as soon as they were introduced somewhere in the world and to provide at least one service in the country that would be impartial, non-commercial and public, at least to the ARC.

Communication services enabled users to communicate among themselves, with international community and to create virtual communities thus enhancing their work and increasing its efficiency. Similarly to communication services, a range of **information services** had been established like directory services, public ftp, web hosting, search services, PGP, media on demand, etc. They improved not only group but also individual work.

Communication and information services, amazing though they may be, left many potential users with the question "and what now?" unresolved in their minds. Majority of users, especially from non-technical areas were actually seeking data. Relevant (scientific) data had to be provided to start the process of acceptance of new technology and recognition of its benefits which would hopefully lead to later overall and universal leverage of the Internet and related technologies in all aspects.

Communication services in their essence offered communication means not content, or at least it was not provided by CARNet. Information services did contain data, but they were provided mostly by users. In addition, CARNet launched a range of **data services,** and they were all about third-party data. They contained scientific databases (Current Content, MEDLINE, Inspec; ...), referral services or portals (www.hr).

Providing a data service requires a technological base (computer servers and high speed connections), data itself and data maintenance. These components are usually provided by different parties. The content was either purchased by the Ministry of Science and Technology (MST) or produced by the service contractor. CARNet role was to organize all the parties in a homogeneous service, to promote the service and to offer user support.

User Support

People usually expect other people to be like them: to share values, attitudes, believes and to behave in the same way. CARNet was launched by pioneers, and they expected everybody else to behave like one: to grab the opportunity, to use new technology and to figure out how it works and how it can be used in most part by himself (Moore, 1999).

Soon, it was discovered that pioneers constitute a very small fraction of academic community and that a whole new track of activities needs to be established in order to attract and involve at least a major part of, if not the entire, academic community (Bates, 1999). Information in the form of brochures, manuals, interactive CDs, Web materials explaining benefits and usage of ICT were provided for different users groups. Merely providing infrastructure and services did not guarantee its successful implementation and users due to continuous upgrading and changing of tools and technologies needed training and support. **Training of end users** was found to be crucial for adoption of technologies and development of skills, and it was organized by CARNet. It was accompanied by a **general purpose helpdesk**.

Institutions needed on-site technical support and maintenance. The technology was new and academic salaries were low, so it was very difficult to get eligible technical staff: system engineers. Therefore, CARNet developed **dedicated educational track for system engineers** and organized suitable separate helpdesk support. To assist system engineers in their work and relieve them of some common activities shared with others, CARNet contracted development and maintenance of standardized set of operating systems, server software and other tools intended to be used in every CARNet node. System engineers were supplied with regular updates of these packages.

Cisco Networking Academy, as the first program for broad professional audience, was introduced, in order to raise the number of skilled technical staff and lower the entry barriers for broader implementation of ICT.

Again, the actual delivery of individual courses was left to educational professionals, but CARNet staff was identifying users needs, defining course outlines, recruiting trainers or contracting institutions and providing funds.

Information technology was new in society and was not part of the curriculum in the formal education. Even when it was, it was in rudimental form and very theoretical. In the first four years, more than 35,000 people were educated in more than 50 **different courses** and the demand for the participation in courses grew. It became apparent that CARNet couldn't provide sufficient training for the community of 100,000 students and 12,000 staff with educational activities in their present form, especially considering new students enrolling in the universities each year (30,000 students in 2001).

In 1998, it was decided to continue with courses as before but introduce the limit on the number of participants from each institution. A parallel activity, **training the trainers** system was established, enabling institutions to train their employees and students as future trainers to run courses for all other employees and students in their institution. In such a way, if an institution wanted to have larger number of staff and students trained, they had to make some

effort: to find future trainers, to motivate them, to devote some space for a special classroom. CARNet and Ministry of science and technology helped them to get appropriate equipment.

In addition to infrastructure, services and education, users needed a variety of software tools and in order to efficiently use them, they also needed continuous assistance. Typical and widely used tools (statistics, modeling, math libraries, etc.) were to be identified. Institutions were sought which had substantial expertise in leverage of the tools. Contracts were, then, signed with them, making them **referral centers** to provide support to users community. In such a way, user community would serve itself in an organized manner. Referral center would organize education for the specific software tool, provide helpdesk, organize workshops, seminars and conferences and also negotiate with vendors for community-wide licenses. CARNet would be monitoring the quality of service, promoting the service and providing funds.

In implementation of new information technologies in a variety of applications and in a complex infrastructure like the CARNet, there arose a huge number of problems that needed to be resolved or agreed upon. Usually, this is a task for **special interest groups**. CARNet invited users to conceive such groups and offered assistance in the form of meeting space and support, travel expenses for representatives to respective international meetings, publishing and promotion of results. However, up to the present moment the response was close to none. Except for a low, activity loose and informal association of system engineers, there had been no user interest group formed.

Visibility of user results, exchange of experiences, checking on new ideas and an easy way to get introduced in "whys and hows" were the goals to be achieved by the **CARNet User Conference**, the annual event initiated in 1999. The attendance had been continuously growing and the satisfaction of attendees had been very high. Despite the low support from taxation laws, conference managed to attract significant sponsorships. They enabled the organizers to award best papers, presenters and presentations with prizes like PCs, palm computers and travels to international conferences. The conference started to act as a hub for other related events that were to take part immediately before or after the conference or would run in parallel.

In the world of the Internet, it seems to be very easy to convey any information to a large number of people. So, one would not expect much trouble for CARNet to announce new services, products and opportunities to the members of academic community. However, there is a catch: how to tell someone about e-mail, by e-mail if they do not use e-mail yet? There is a problem in the reverse communication as well: if a number of people from an institution are suggesting or demanding one type of service and the other group is advocating something exactly opposite, what should CARNet do?

In order to assure appropriate dissemination of information to end users in institutions a network of CARNet co-ordinators has been established. Every institution appoints an employee as a CARNet coordinator whose primary role is to act as a liaison officer. News, plans and other information sent from CARNet are relayed to employees and students. Likewise, problems, suggestions, needs and events in an institution are consolidated within the institution and communicated back to CARNet. All coordinators together constitute "Users Council" who has an advisory role to CARNet management influencing annual programs and strategic plans.

Since 1997, CARNet member institutions have been reporting annually about the usage of resources available through CARNet services (Appendix 5). In 2000, the total of 164 institutions submitted reports. Comparison across years indicates speed of ICT penetration

and the level of its utilization and is differentiated across specific user groups. It also addresses importance of individual CARNet services and activities to end-users. The annual reports about the usage of CARNet infrastructure and services and institution's needs have been filed by CARNet coordinators and endorsed by top management of individual institutions. Thus, the reports are considered as official feedback from users.

Change Agent

The far-reaching goal of the CARNet activities was to make impact on the national level, outside academic community. Academic community on institutional and on the individual level was to be the partner, CARNet acting as a coordinator and organizer.

CARNet aim was to collect knowledge and experience in the field of information technology and implement them into academic network. The use of global information infrastructure such as the Internet and the Internet-based information services was the prime interest.

It was expected that after graduation students would leave the academic community, trained to use information technologies, and be willing to build or require that type of infrastructure at their working places. It was also expected that academic and research community would gain experience in implementation of ICT in their respective professional areas and thus be capable to act as consultants or contractors in implementation outside of academic community in areas like education, judicial or health care system, public administration or culture. However, in order to gain the competence, academics needed hands-on experience on real-life problems.

Therefore, in order to support pioneers in implementation of ICT in different areas, to solve a particular problem using ICT, or to make a first step in a big project, CARNet ran a range of **pilot projects** (www.CARNet.hr/projects) in a broad area as a complementary segment of its activities. Their goals were to prove and measure the benefits of ICT implementation, to discover the limits and estimate the costs, while building the knowledge, experience and thus competence of academic community. Projects were performed by groups and institutions from academic and research community on the contractual basis. CARNet was tendering assignments or accepting proposals, financing, monitoring and promoting projects and results.

Every occasion was used **to promote usage of information technology**. Upon request from organizers, CARNet participated in various events, including non-academic, providing infrastructure like Internet access, videoconferencing or streaming, technologies that were not commercially accessible. Presenting overview of the technology and trends, gaining experiences in different projects or new services, CARNet was promoting ICT to different professional and user groups.

As an independent, non-commercial agency, CARNet had initiated and maintained several **national services** important for whole Croatian Internet community. With this act, CARNet ensured specific infrastructure service, common for the Internet service providers sector, enhancing their operation while lowering the costs. The most important services are Domain name service (DNS), Croatian Internet Exchange (CIX) and Computer Emergency Response Team (CERT).

Defining the policy of Croatian Internet top-level domain ".hr", administration of domain names (DNS) under it, coordinating operation, promotion and legislation, is the role for a non-profit, impartial body, and thus CARNet assumed it. To motivate the industry to create national information space, domains are assigned to users free of charge.

Exchange of the traffic among Croatian ISP's through Croatian Internet Exchange (CIX), lowers the burden for networks outside Croatia and decreases the communication costs.

CARNet CERT (Computer Emergency Response Team) ensures cooperation among ISPs, users, legal bodies and international community, on the topics of education, prevention and response on security problems in the network on the national scale.
More active methods were possible and expected as CARNet tasks in the further development of public information systems: strategy development, project design, project management, executors supervision, etc.

Organizational Development

During the ten years of CARNet, its organizational form (Mintzberg, 1993) was continuously changing (Appendix 6). However, the metamorphosis can be grouped in four phases.

First Phase (1991-1995)

CARNet started as a project. In the first phase of stable, ongoing operation, CARNet was fully run by University of Zagreb Computing Centre (SRCE), financed and coordinated by the Ministry of Science and Technology.

Young enthusiasts worked in SRCE, dedicated to provide good service to academic community, performing all communication, computer, user-support and information services. State-of-the-art technology and noble mission, in the time of war and overall depreciation, made them eager and curious to show they could make a difference. That was a time for learning and cooperation, without strong organization, planning and sustained financing.

CARNet project was initiated by a young (age 31) engineer who was immediately appointed the project director. Two years letter, in 1993, he was invited and appointed Deputy minister of science in charge of information technology. This gave the project the next boost in importance and financing. He continued to be in charge of the project.

Second Phase (1995-1998)

SRCE was the computing centre of one of four Croatian universities. Although SRCE was implementing CARNet in all universities political conditions did not allow to change its constitution and broaden its mission or "jurisdiction".

Only one-third of all SRCE employees were engaged in CARNet operation. The company as a whole was not supportive to further challenges, such as international cooperation, public relationships and customer management. The project was growing and spreading. Management in terms of project management and human resource management was becoming the predominant part of CARNet activities and SRCE management was neither competent nor ready for these non-technical types of activities. Marketing and promotion were on the edge of blasphemy in the low-salaries, engineers dominated culture. Therefore, managing tasks were spontaneously organized and performed by the Ministry of science's newly formed department for Information technology. Young engineers also populated this department but they started understanding that the key of future success of the project lies in professional management and completely new working culture. It was clear that a major change needed to take place.

In 1995, CARNet agency was put in operation. It was fully owned and financed by the government but largely independent from other state authorities. The idea was to create an

organization in charge of organizing the potentially huge and endless numbers of projects. The actual work of running communication infrastructure, services, education and other activities was to be outsourced to academic community or to the market (Kowack, 1995).

A young engineer was appointed for CEO. He was a good engineer but without any managing experience. It was believed that he will learn flying on his own. He was very systematic and professional. His inclinations laid in strong hierarchy and a rigorous financial control, which were established.

CARNet operations were run by CARNet Executive Committee (CEC) formed from CEO and four deputies, leading four departments: infrastructure, services, R&D and special projects. CARNet was still very much relying on enthusiasm and learning by doing. It was impossible to find such people outside of community, so three deputies were appointed from the "inside": SRCE and Ministry, joining CARNet on the contractual basis. It was clear that this dual role (and sometimes conflict of interest) would pose the problem but it was also hoped that it would generate some benefits. Besides, it was expected to last only a few months, a year at most until "real" deputies were found.

The Deputy Minister, founder and godfather of CARNet, was the chairman of the CARNet Board. He was always present at the CEC meetings, and all strategic, especially technological decisions, were strongly influenced by him. He was deeply involved, and was sheltering young agency from the outside problems.

All those dual roles produced continuous tensions between development and operation (CARNet and SRCE), future and present priorities (Ministry's and CARNet's), "doing right things" and "doing things right" cultures.

Third Phase (1998-2000)

CARNet didn't have it's own building. It was dispersed in four locations, instead. Management was caught by surprise when four different subcultures evolved within one organization. In 1997, it was becoming obvious that CARNet organised in four divisions, with four different cultures, priorities and strategies, and only about 30 people altogether could not deliver what had been required from it. Besides, full time management staff was required, among other things, to employ fully all the employees and partners potentials. The first CEO, after three years of building an organization almost from scratch, got tired from management and decided to leave.

For the expected development of organization and nation-wide role, to fight scarce resources and passive environment, for further pushing of ICT into the public sector, the position was offered to chief of operations in the Ministry. She was already responsible for special projects, corporate culture and human resource management in the period of strong divisions. Engineer by education, manager by her aspirations and leader by the nature, she was the choice.

She moved from Ministry to CARNet and was appointed CEO soon to be followed by the deputy for services who was transferred from SRCE to CARNet to become vice CEO. The new, flat organization was chosen (Appendix 6) believing it could be better accommodating for project type of work and intensive knowledge sharing it required. Almost everybody was given responsibility for his or her segment of job. All of a sudden there were no (big) bosses anymore and everyone was the (small) boss.

Employees belonging to more structural departments, like infrastructure and research and development, had a rough time. Their safe haven was gone, and teamwork and responsibility has put a lot of burden on them.

At the same time, project organization was emerging, providing the platform for the multidisciplinary teamwork and more structural involvement of non-employees (partners, part-timers). Strategy was to outsource and contract all the operation, even ("hard core") research and development. That meant, "real work" and success were given to other organizations, and only "dirty administrative tasks," like running the projects and writing project documentations and contracts, remained in CARNet.

Many good engineers left CARNet in this period (Appendix 8). Only those who liked fast drive and high risk stayed in CARNet. That was time of learning new skills, large investment in non-technical education of employees, transformation from all-engineers organization in multidisciplinary organisation. It was also the time of building alliances and fighting for the sufficient budget to preserve the pioneering position among national networks.

Fourth Phase (2001-Present)

Numerous, complex, different activities and lack of strict formal structure imposed project work as the natural way of doing things. Those who resisted "administrative project management work" left. Support functions were developing. More people began to work for CARNet as contractors, employees of partner organisations or part-timers.

In the flat organization, a small management group became a bottleneck. Many parallel projects required distributed responsibilities, but still intensive cooperation.

It was time to introduce new rules of the game — adhocracy (Appendix 6). Adhocracy (Waterman, 1992) with its inefficient mutual adjacent coordinating mechanism, with lots of liaison functions, with no operational core, had become the new stage of CARNet evolution.

Majority of senior employees became managers, mentors and coordinators. Even more, responsibility was distributed among employees, especially those who were in positions of project managers.

Most of the services were formally outsourced, in the first place to SRCE, the oldest and still the most important partner. Skills in negotiation, contracting and coordinating became natural requirements for CARNet employees.

Acquisition of the new skills, like knowledge management, alliance building and fund-raising had progressed. Unfortunately, emphasis on the non-technical competences caused animosity and lack of purpose and focus by engineers. A strong chief technical officer became necessary, to add technical view and priorities to the management team, as well as to link technical teams and their goals with overall goals.

Financing

CARNet was a governmental agency, financed directly by the state budget. The benefit it offered was a planned and secure "income" allowing efficient planning of activities. CARNet budget was to be also stable over the course of years, which would make long term planning possible.

However, experience had shown that execution of the budget rarely reached the planned sums and that it varied throughout the year. In addition, every new government administration needed to be familiarized with CARNet role and needs. This took time and usually caused disruptions in financing (Appendix 9).

Budget expenditure limits also limited salaries while not recognizing particularities of ICT professionals and high market demand for them. Expenditures were also limited in case

of education, travelling and other items characteristic for young and new types of organizations.

Despite the problems, CARNet managed to increase, although not continuously, its budget over the years. However, a major part of the budget went for telecommunication services. Legislation was still supporting the monopoly of the national telecom operator, which allowed it to keep much higher prices than those in deregulated markets. CARNet was not successful in making its activities a state priority, which would force the monopoly holder to treat CARNet differently from other consumers.

From the day one, all CARNet services were completely free of charge for end users, both institutions and individuals. Other national networks often charged academic institutions for access to the Internet. CARNet considered there would be no benefit from it since, almost all academic and research institutions were government owned and financed from the budget. If they had to pay for services, they would put pressure for the increase of their budget. Thus, the money would come from the same source but encumbered with more administration, control and accounting expenses while giving up benefits of economy of scale.

Croatian economy had barely survived the war losses but was on the way to recovery. Companies and universities alike were still trying to figure out what the market economy was all about. Many decision makers still lived in the past, in the concepts on the benefits of the planned economy. Tax regulation did not favour donations and sponsorships for educational or scientific purposes.

In addition, advanced services were not always the priority for expenditure decision makers in many academic institutions. Thus, the plan was made to finance communication infrastructure and services centrally from the budget and then to transfer the responsibility of financing on to users and their institutions at the moment when the critical demand had been created in users community (Jennings, 1995). This would mean that CARNet would have to start charging for those services.

There were some suggestions, mostly from the Ministry of finance who is in charge of state budget, that CARNet should increase its budget by selling its services on the market to non-academic users as well. There were examples of similar behaviour in some Central European countries. However, CARNet was opposing and resisting these suggestions for several reasons. Firstly, CARNet had much broader range of activities than any other national networking organisation. Most of those services were oriented strictly to academic users, which chronically lacked funds to pay for services. Secondly, based on its non-profit and academic status, CARNet was eligible for significant discounts in purchase of hardware, software and services, both on domestic and international markets. If CARNet was to buy them at commercial prices, it would never manage to sell advanced services at an economical price. Thirdly, CARNet role was to be a pioneer and to cater to pioneers. This is almost always not profitable.

While most of Central and Eastern European countries enjoyed benefits of EU funds for development of academic networking, due to the war and political relationships, Croatia did not appear to be eligible for them. Thus, in the whole period, CARNet did not receive any significant international donation or support of any kind. In addition, international connectivity, sponsored by EU for other countries, had to be acquired, from the national monopoly holder, at extremely high prices despite big education discounts.

CURRENT CHALLENGE/PROBLEMS FACING THE ORGANIZATION

Network Infrastructure Consolidation

CARNet's 1995 projection was that, after deregulation of telecommunication market (in 2003), major part of its connectivity services will become commodity products and, due to the economy of scale, would be available at a price on the market. This, however, meant that CARNet would have to cease to operate its communication infrastructure as a private network, and be buying the service. The only exception would be much smaller experimental test bed used for piloting new technologies and services not yet available on the market.

However, this did not and will not happen in the next several years (to 2004 and beyond). There are several reasons for that, all mutually intertwined and interdependent:

- usage of ICT did not grow as expected and penetration to various activities was still very low, making the market still weak;
- government has not initiated informatization of public services, which would stimulate consumption and development of public networking infrastructure; and
- monopoly has been prolonged (to 2004) allowing high prices.

Therefore, CARNet has to continue operating and enhancing its private network. However, this is becoming increasingly difficult due to the fact that:

- after privatisation of the national telecomm operator (HT) the monopoly period has been prolonged. Private owner (Deutsche Telekom) has increased prices and shows no interest for special arrangements with CARNet. Instead, CARNet is treated as its competitor;
- HT is technically and organizationally not able to provide advanced services;
- HT does not want to sell low level services like copper lines or dark fibre (unbundling the local loop) which would allow CARNet to install its own advanced equipment; and
- HT is forcing CARNet to use its medium level services like 2 Mpbs digital lines, but even with the contract signed, HT does not deliver them at all, or does so with unacceptable delays of more than six months.

Continuation of this situation is making CARNet network obsolete fast. A solution must be found and implemented quickly. Currently, CARNet has been seeking its own way out in two directions: technological and legislative.

Technologically, CARNet has been piloting wireless LAN/MAN sub-networks (2.4 GHz spread-spectrum de-regulated solutions). On the legislative side, CARNet is exploring cooperation with other would-be providers after complete de-monopolization of telecommunications that is expected to occur in the coming years, as well as possibility to partner with owners of eligible infrastructure even before de-monopolization. For example, the town sewage company owns drainage system connecting every building in the town. Thus, a pilot project is running exploring technical, organizational and legal aspects of using sewage system to deploy CARNet's own fibre infrastructure within the city. Further, the national power company has already laid fibres in the cables of the power lines connecting cities. Partnering with them would enable CARNet to have alternative supplier of connections on the national level.

These potential alternative telecommunication providers appear to be showing some interest, though it does not seem to be strong enough probably because they do not yet know

where to start. In addition, all of those companies are still state owned and are waiting for the privatisation decisions from the government.

On the international level, in these ten years, CARNet has been a user of European networking infrastructure, being connected to the node in Vienna. It has always been CARNet's vision to become the connecting network between the neighbouring countries. However, it has not been possible due to the lack of traffic interest among the western neighbours as well as due to the lack of political will to approach the eastern neighbours. Fortunately, new EU project GEANT has decided to establish a POP (Point Of Presence) in Croatia, thus connecting CARNet with the Austrian and Hungarian Networks. This gives hopes and represents a foundation for possible establishing of connection between CARNet and other networks in the eastern countries.

The Level of ICT Usage in ARC

Deploying a national networking infrastructure and establishing a wide range of services was a huge enterprise with no previous example in the country. CARNet was concentrating on fulfilling those tasks and believed that all users will eagerly embrace and use them as soon as they were available.

It did not seem to be the case, so CARNet had decided to shift the emphasis to facilitating and stimulating the usage and implementation of ICT in the academic community's life and work. In a number of surveys, CARNet was asking users about their ideas of innovative usage of ICT in what they do. The response was more than weak. It seems they may lack knowledge and experience to answer the questions regarding their primary needs or problems that ICT can fulfil or solve, not yet being able to consider how to plan to use ICT.

However, CARNet cannot fulfill this assignment alone. Students are the key alliance, because their requirements towards universities will create the demand and need for ICT. University administrations and Ministry can and should influence the change by launching projects and imposing various standards and requirements on level and quality of education and research.

Change Agent

The soft, passive role by promoting, influencing market, students and graduates and educating project leaders have been assumed by CARNet. This role should be intensified by increasing the number of employees, organization partnerships and omnipresent promotion.

However, the active form basically has not been used. Government did not launch into "informatization" of public systems like health, education, government administration or judicial system (European Commission, 2000). Those who initiate similar projects on institutional level seem not to understand the importance of project preparation and management and/or to recognise CARNet as eligible partner and resource of knowledge and experience.

As an example, primary and secondary school system is not only very similar to academic community but also naturally connected. CARNet experiences, infrastructure and services could be easily used, multiplied, cloned for the educational community. So far, there have been no requirements towards CARNet from the authorities despite CARNet showing willingness to take part and sending active messages regarding it.

The issues are:
- how to raise awareness of authorities for the needs of huge ICT systems and CARNet's possible role in their establishment;

- when awareness becomes present and demand for CARNet participation significantly outgrows CARNet's current capacities, should a new agency be formed, commercial spin-offs stimulated or CARNet repositioned and reshaped; and
- all activities performed by CARNet so far are only a small fraction of the change agent's activities. In Croatia there is no other example of a change agent and even on the global scene there are few with the nation-wide role. Thus, the question is: where to gain required knowledge in order to become a true and successful change agent on the national scale.

Human Resources

From the very first day of CARNet, people were the primary resource. CARNet always looked forward to "people flow" through the organization since it helps influencing society and transferring knowledge and organizational culture. However, to run efficient services and projects and to create, develop, maintain its own culture and transfer it to the novices, an organisation needs a core of "old" professionals. Market demand for such people is tremendous and their price is rocketing. CARNet has not even begun to fill all the job vacancies, especially in top management positions.

CARNet, being financed by the budget, has serious limitations not only in the area of salaries but also in a number of other expenditures like education, travel, equipment, office comfort, etc.

The issue, at present, seems to be how to attract and retain key personnel. So far, motivation was based on challenging projects, learning and education, warm-hearted atmosphere. However, the key personnel that grew with CARNet and is getting older, forming families, thinking about the career seems to be shifting emphasis on the importance of financial compensations.

This need can be met in two ways:
- CARNet should ensure some kind of additional income that could be used for increasing salaries and other expenses or
- key personnel should have reduced working hours and be allowed to earn additional income working on projects both in CARNet and outside.

Financing

There is a range of reasons to commercialise some of CARNet services:
- getting all required finances from the budget is becoming increasingly difficult with growing suggestions to commercialize some of the services;
- there appear to be emerging potential customers outside academic community interested in some of the services like education, connectivity, consultancy, project management, etc.;
- there are views that if academic community were to pay for some of the services, they would value and use them more; and
- some of human resources requirements could be fulfilled with additional, non-budget income.

The negative sides of commercialisation cover:

- the fear that budget sums might be decreased even more because of false expectations that everything could be commercialised, which is not true for the backbone and international connectivity;
- discounts for educational and non-profit organizations currently used might no longer be applicable;
- tensions among employees working on profitable projects and those on budget would be developing; and
- the basic role of academic and research community is centred on the area which is rarely profitable which transposes to corresponding ARNET activities.

There is evidence and examples on international scene that there exists interest in charitable and non-profit financing of activities similar to CARNet's. This might prove to be a significant source of income and replacement for expected budget cuts. The issue is whether to establish a fund raising department or to form a separate trust or foundation that would primarily finance CARNet's activities.

FURTHER READINGS

Senge, P. (2001). *The Fifth Discipline: The Art and Practice of the Learning Organization*. Zagreb: Mozaik knjiga Internet Sites.

CARNet. (2000). CARNet Submission for Croatian Strategy for 21st Century. http://www.CARNet.hr/strategy.

CARNet Information Service. http://www.CARNet.hr.

CARNet Network. http://www.CARNet.hr/network.

CEENet. (1997). CEENet Tartu Declaration, Tartu, Estonia http://www.ceenet.org/ceenet_tartu.htm.

GEANT Network. http://www.geant.net.

TERENA compendium. http://www.terena.org/compendium.

UCAID. (2002). http://www.internet2.edu/ucaid/.

REFERENCES

Bartolincic, N., Pezelj, I., Velimirovic, I., & Zigman, A. (2000). The implementation of broadband network technologies in CARNet. *Proceedings of SoftCOM 2000, Split - Rijeka, Croatia, Trieste - Venice, Italy*, October 10-14, pp. 937-946.

Bates, T. (1999). *Managing Technological Change: Strategies for College and University Leaders*. San Francisco, CA: Jossey-Bass.

Behringer, M. (1995). Technical Options for a European High-Speed Backbone. *Proceedings of the JENC 6, Tel Aviv, Israel*, May 15-18, 513-522.

Beki, Z., Gojši, J., & Pale, P. (2000). The role and strategy of an ARNET in a developing country. *Proceedings of SoftCOM 2000, Split - Rijeka, Croatia, Trieste - Venice, Italy*, October 10-14, pp. 955-960.

European Commission (2000). *IST 2000 Realising an Information Society for All*. Luxembourg: Office for Official Publications of the European Communities.

Jennings, D. (1995). An Internet development model for Europe. *Proceedings of the JENC 6, Tel Aviv, Israel*, May 15-18, 522-523.

Kirstein, P.T. (1995). A user's view of the EU research networking programmes. *Proceedings of the JENC 6, Tel Aviv, Israel*, May 15-18, 531-532.

Kowack, G. (1995). Concepts for provision of Internet services to academic and research community. The EUnet perspective. *Proceedings of the JENC 6, Tel Aviv, Israel*, May 15-18, 523-524.

Mintzberg, H. (1993). *Structure in Fives; Designing Effective Organizations*. New Jersey: Prentice-Hall.

Moore, G. (1999). *Crossing the Chasm*. New York: HarperCollins Pulishers, Inc.

Pale, P., Bulat, D., Maric, I., Simicic, L. & Vujnovic, V. (1992). Concept and development of CARNet, *Proceedings of the 14th International Conference on Information Technology Interefaces, Pula, Croatia*, September 15-18, 265-272.

Seršic, D., Pale, P., Vucic, R., Zigman, A., Bartolincic, N., & Maric, I. (1996). A nation wide 155 Mbps ATM academic network reach to the desktop. *Mipro 96*, Opatija, Croatia.

Tesija, I., Vucic, R. & Zigman, A. (1997). Applications of broadband digital networks. *DORS'97*, Zagreb, Croatia. http://cn.carnet.hr/arhiva/1997/970417/pred1/index.html.

Teteny, I. (1997). Paving the highway by PHARE. *Proceedings of the JENC7, Budapest, Hungary*, May 13-16, 242-243.

Waterman, R. (1992). *Adhocracy: The power to change*. New York: W. W. Norton & Company, Inc.

INTERNET SITES

CISCO. (2002). Internetworking Technology Handbook. http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/index.htm.

Croatian Bureau of Statistics. www.dzs.hr.

BIOGRAPHICAL SKETCHES

Predrag Pale obtained his BSc and MSc degrees in electrical engineering from the University of Zagreb, Faculty of Electrical Engineering, where he is lecturing today. He has been designing computer hardware, operating systems, applications and computer networks, but most of his twenty years of professional experience lie in the area of ICT applications: from medicine to civil engineering, commerce, financing, libraries, news media, education, to government administration. He started Internet in Croatia in 1991 with CARNet project, Scientific Information System in 1994 and National Information System for Libraries in 1998. From 1993 to 2000 he had been appointed a deputy minister of science and technology. His primary interests are in the application of ICT in education, medicine and other public systems. He is frequent speaker at international events about the future of the cyberworld and on issues of privacy and security of information systems.

Jasenka Gojsic obtained her BSc in telecommunications and has had 10 years of experience in networking. She had worked in Croatian Telecom in information services department for two years. She joined CARNet project in Ministry of Science and technology in the early phase, in 1993. Since then, she has been the project leader, deputy chief executive officer, and for the last four years chief executive officer of CARNet. Her prime interests are organization and human resource management. She has obtained MBA degree in those fields. Ms. Gojsic strongly believes in ICT being a vehicle to the knowledge society.

APPENDIX

Appendix 1: Milestones (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix1)

Appendix 2: CARNet Network Backbone (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix2)

Appendix 3: CARNet network backbone in city of Zagreb (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix3)

Appendix 4: CARNet Network Structure (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix4)

Appendix 5: Users Feedback (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix5)

Appendix 6: Organisational structure (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix6)

Appendix 7: Employees (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix7)

Appendix 8: Finance (www.FER.hr/Predrag.Pale/publications/ACIT/Appendix8)