EUROPEAN RESEARCH PROGRAMMES IN NETWORK TECHNOLOGIES

Abstract

European Union has undertaken the last decades main actions for funding research and development of innovative information technologies and especially Network technologies. In this paper, except from a presentation of the main European actions key, there will also be a brief presentation of some innovative research projects that were developed the last ten years and had a major role in the improvement of the scientific and technological basis of Community businesses and the enabling of them to compete in the global market.

During the period 1994-1998, activities of the European Union RTD in information technologies were carried out under the Fourth Framework Programme (FP4) with a total budget amounted to ECU 13,215 million. The main programs then were Advanced Communications Technologies and Services (ACTS), Information Technologies (ESPRIT) and Telematics Applications.

The ACTS developments have bridged between technology and general service developments and open up new market opportunities in synergy with liberalisation of telecommunications infrastructure and service provision, as also helped electronic commerce, new teleworking and tele-co-operation systems

The results of ACTS were the infrastructure for the beginning of the new research program in Information and network technologies. The Information Society Technologies (IST) theme in the 5th Framework Programme of EU RTD was defined in the Commission's proposal for Creating a User Friendly Information Society was agreed at the Council of Research Ministers on 22nd December 1998 with a total amount of funding around the 3600 million Euro.

1. Introduction

This paper's main objective is to show how sensitive was and still is the European Union in developing an infrastructure on innovative information technologies and especially Network technologies. The last decades EU has undertaken main actions for funding research projects that were developed the last ten years and had a major role in the improvement of the scientific and technological basis of Community businesses and the enabling of them to compete in the global market.

In this point we must define that by the word Networks we are referring:

- to their physical substance, e.g. bridges, Routers, Lan, Wan, cables, Ethernets and others.
- to their operational and functional substance, where we study the interconnection and interaction of resources in general

The European research funding was introduced in five frameworks, with many thematic programs, with 4 to 6 key actions (depending on the funding program) which are going to be described below.

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2. European Union RTD

2.1 Introduction

European Union activities in the area of research and technological development (RTD) are driven by the need to improve the scientific and technological basis of Community businesses to enable them to compete in the global market. Far from seeking to replace national initiatives and powers, the principal role of EU action is to extend, complement and enhance the research activities of the Member States in order to address the three major weaknesses of European RTD to its competitors:

· A proportionately lower level of investment in RTD;

· A lack of coordination at the various levels of the research and technological development activities, programmes and strategies in Europe;

· A comparatively limited capacity to convert scientific breakthroughs and technological achievements into industrial and commercial successes.

In recognition of the need for a concerted and coordinated effort at European level, EU RTD has evolved considerably over the years both in terms of its relative importance as a Community policy and the financial resources invested by the Community. Although the Community began providing support for research activities in the late 1950s (mainly in the nuclear sector), the big breakthrough came in the 1980s with the establishment of the first generation of multiannual Framework Programmes and the elevation of research and development to the status of a "Community Policy" in the Single European Act.

Since 1984, Community RTD activities have been strategically planned and coordinated within five multiannual Framework Programmes, the purpose of which is to set out the priority areas to be covered during the life of the programme. To date, over 7,000 projects across a wide variety of sectors have been financed under the Framework Programmes. These have involved thousands of European companies, research centres and universities.

Framework Programmes are instruments, which reflect the scientific and technological priorities of their particular time, as well as the prevailing economic and political circumstances. Following the grouping of Community research activities under the First Framework Programme (1984-87), the main aim of the Second Framework Programme (1987-91) was to develop the technologies of the future, in particular in the area of information technology and electronics, and materials and industrial technologies.

While the Third Framework Programme (1990-94) broadly followed the same lines as its predecessors, an increased emphasis was placed on activities relating to the dissemination of research findings, life sciences and technologies and the

training and mobility of researchers. The content and structure of the Fourth Framework Programme was largely influenced by the RTD provisions introduced by the analysis and recommendations of the Maastricht Treaty.

The Fifth Framework Programme (FP5) sets out the priorities for the European Union's RTD activities for the period 1998-2002. Like its predecessor, FP5 has two distinct parts: the European Community (EC) framework programme covering research, technological development and demonstration activities; and the Euratom framework programme covering research and training activities in the nuclear sector.

A budget of 13,700 million euro has been agreed for the implementation of the European Community section of FP5. Combined with the 1,260 million euro allocated to the Euratom programme, this should bring the global budget for research during 1999-2002 to 14,960 million euro. (This represents an increase, in absolute terms, of 4.61% compared to the Fourth Framework Programme.)

FP5 also differs substantively from its predecessors. It has been conceived to help solve problems and to respond to the major socio-economic challenges facing Europe. To maximise its impact, it focuses on a limited number of research areas combining technological, industrial, economic, social and cultural aspects.

One of the major innovations of the Fifth Framework Programme is the concept of "Key actions". Implemented within the specific programmes, these flexible instruments are targeted at achieving solutions to topics of great concern in Europe. "Key actions" will mobilise the wide range of scientific and technological disciplines - both fundamental and applied - required to address a specific problem so as to overcome the barriers that exist, not only between disciplines but also between the programmes and the organisations concerned.

2.2 The Fourth RTD Framework Programme 1994-1998

During the period 1994-1998, European Union RTD activities were carried out under the Fourth Framework Programme (FP4) and the parallel Euratom Framework Programme covering research and training activities conducted in the nuclear sector.

The total budget for both EC and Euratom Framework Programmes amounted to ECU 13,215 million (EC: ECU 11,879 million, Euratom: ECU 1,336 million).

Information and Communication Technology programs that were carried out, were:

- Advanced Communications Technologies and Services (ACTS)
- Information Technologies (ESPRIT)
- Telematics Applications

2.3 Fifth RTD Framework Programme (1998-2002)

The Fifth Framework Programme (FP5) sets out the priorities for the European Union's RTD activities for the period 1998-2002, with a budget of 13,700 million euro. Like its predecessor, FP5 has two distinct parts: the European Community (EC) framework programme covering research, technological development and demonstration activities of 14,960 million euro; and the Euratom framework programme covering research and training activities in the nuclear sector with the 1,260 million euro .

The Information Society Technologies (IST) theme in the 5th Framework Programme of EU RTD was defined in the Commission's proposal for Creating a User Friendly Information Society was agreed at the Council of Research Ministers on 22nd December 1998 with a total amount of funding around the 3600 million Euro.

3. Advanced Communications Technologies and Services (ACTS)

3.1 Introduction

The research and technology developments supported from 1994 to date in this programme have capitalised on the results of the two phases of the RACE programme, from 1988 to 1994. They have therefore built on European strengths - world leadership in mobile communications, in optical communications; in digital image and video systems and in complex network management. They have also focused much more on the Internet and world-wide web technologies and platforms, which emerged as complementary alternatives to traditional communication networks and services in 1993. The RTD in the ACTS programme has therefore established a sound basis in Europe for convergence and integration of broadband services: the original objective of the 10 year RACE/ACTS strategy: to develop Integrated Broadband Communications (IBC) supporting image, text and voice services in a coherent way.

The ACTS developments have also bridged between technology and general service developments to open up new market opportunities in synergy with liberalisation of telecommunications infrastructure and service provision; notably with electronic commerce: for new teleworking and tele-co-operation systems and for access to our cultural resources.

3.2 The objectives and the focus of the programme

The ACTS RTD has most notably contributed to single market policy objectives through its contribution to standardisation and coherent infrastructures and service deployment. The ACTS programme has been implemented in co-ordination with the above policy initiatives.

- *Mobile multimedia services*

  The transition from GSM mobile telephony to 3 rd generation multi-media systems is both a major technological challenge and a key economic development goal for Europe. The close linkage between RTD in ACTS and the EU policy initiatives led by DG XIII in 1997-98 enabled simultaneous agreements to be reached in industry and with Member States about common technical protocols, spectrum use and commercial service launch by 1st January 2002.

- *Electronic Commerce*

  Advanced communications systems are now essential to business competitiveness in world markets. ACTS technology developments, and particularly the trials of use in a variety of business environments, have already shown substantial benefits. ACTS projects have led the way in key areas of networking of business activities and in electronic-commerce. The ACTS RTD also provided a solid foundation for business consensus on key interoperability issues.

- *New Ways to work*

  Flexibility in time and place made possible by new communication systems is also central to European employment strategies in an Information Society. In close collaboration with DG V (responsible for social and employment policy), ACTS projects, working in a "concertation chain", have linked technology developments to requirements for telework; to the social dialogue with major employers and trade unions about introduction of new working practices, and to major public awareness initiatives.

The main objective of the programme was to develop advanced communications systems and services for economic development and social cohesion in Europe, taking account of the rapid evolution of technologies, the changing regulatory situation and opportunities for development of advanced trans-European networks and services. In addition, specific objectives were set in the six areas of the programme:

- Interactive digital multimedia services
- Photonic technologies
- High-speed networking
- Mobility and personal communication networks
- Intelligence in networks and service engineering
- Quality, security and safety of communications services and systems

Above there will be description of those key achievements that are referring to network and communication technologies.

3.3 Key achievements regarding Network technologies

3.3.1 Photonic Technologies Area

3.3.1.1 Optical fibres are the backbone

Almost every telephone call you make (including mobile), all digital data transmissions, every TV broadcast and all traffic on the Internet backbone are already carried over fibre optic cables. Photonic (or optical) communications technologies use light as their basic transmission medium. Such technology is capable of moving larger amounts of information over longer distances than traditional electronic communications networks, providing the extra capacity needed to support the growing bandwidth demands from the Internet and the World Wide Web, and from mobile telephone services such as GSM (Global System for Mobile Communications) and UMTS (Universal Mobile Telecommunication System).

3.3.1.2 Higher capacity

It is now clear that the future European broadband information infrastructure will be based on optical fibre technology and DWDM (dense wavelength division multiplex) optical networks. The long-term strategic goal of the research work in optical networks is therefore a Europe-wide integrated infrastructure which can efficiently support the wide diversity of present and future applications and services, can meet the increased capacity demands of these services and ensure their delivery at affordable cost to all users.

3.3.1.3 Lower costs

Along with increased competition, wider deployment of photonic technology has also been a key driver of cost reduction for long distance calls over the last decade. Huge information carrying capacity and near zero transmission cost per unit makes it the ideal network medium for the Information Society. The Projects in this domain have addressed the development of essential optical technologies and network architectures; and longer-term issues on which industries need to agree common approaches, notably protocols and standards. The results of this research are now being exploited to support the rapid world-wide deployment of multi-wavelength optical networks.

3.3.1.4 Making technologies work together

Issues addressed in optical network development include: optical switching, signal processing and control; techniques for very high-capacity, (multi-gigabit) transmission; new concepts in design, network management and control of photonic networks, demonstrating the increased flexibility possible with optical technology; and migration paths from present-day networks based on electronic switches, to future hybrid and all-optical networks.

The work of the Projects has addressed the concepts and the design of the future trans-European broadband network architecture (including number of layers, partitioning and functionality of each layer, nature of the gateways between each layer, etc.), the performance and evolutionary strategies regarding user needs, operator views and technological capabilities of equipment manufacturers. Concepts have been developed for routing and multiplexing. The work covers different types of network architectures, particularly multi wave length networks, evolution, new concepts and control, management techniques for photonic networks and interworking issues between different photonic networks.

3.3.1.5 All Optical Networks

An all-optical communications network represents the best means of achieving the required bandwidth for future multimedia applications and on-line commerce. Such networks are capable of switching huge amounts of data without performing any inefficient opto-electronic conversions.

Work carried out in the ACTS Programme has already included wide-scale field trials of advanced communication scenarios. The projects OPEN, METON, PHOTON, WOTAN and MOON successfully demonstrated field trials of all-optical network scenarios to build the foundation for the European Information Infrastructure (EII). In an integrated field trial, project PELICAN utilized successes from four projects (OPEN, MEPHISTO, PLANET and KEOPS) to establish a Pan-European optical broadband transport and access platform. The SONATA project has established an all-optical distributed switching network. Such a “switchless” network would eliminate the need for ATM cross connects or SDH, as well as telephone switches, thereby creating a viable alternative to today’s multi-layer communications networks. Fully optical networks, suitable for corporate users, were successfully implemented by ACTS projects METON, KEOPS and COBNET. Only at the edges of the network (e.g. at the public telephone switches, corporate networks, customer premises) does an electro-optical conversion take place. To achieve this, the projects established the network concept and defined the requirements. The design activity alone led to the set-up of commercial companies developing and manufacturing optical components for commercial applications. Finally, life was brought to the network by developing and implementing its "intelligence", i.e. the management system.

3.3.1.6 Multiple wavelength combinations

A key driver of the transition to the all optical network is Wave Division Multiplexing (WDM). This increases the transmission capacity of the backbones by allowing up to 80 different wavelenths channels to be combined on existing fibres. WDM solutions can be deployed with one wavelength on day one, yet engineered with the capability for expansion to one hundred times that. By designing in scalability, network operators can lock onto savings as the network evolves to

accommodate larger capacity. Secondly, as new optical network elements become commercially available, these can be incorporated into the network, allowing a smooth evolution to an all-optical network.

The signs of fibre capacity exhaustion and congestion were key factors in driving research into the deployment of WDM. The Projects OPEN, METON, PHOTON and MOON all successfully demonstrated the advanced WDM network capabilities in the field trials throughout Europe. Further capacity expansion can be realised through dense wavelength division multiplexing (DWDM). This was successfully demonstrated in the MOON project: researchers were able to send data at gigabits/sec across a fibre spanning 1570km. One project partner (Siemens) routed data back and forth across an optical link, measuring 523km between Munich and Vienna.

3.3.1.7 Multi-Service Access Networks

The results of the ACTS Projects indicate how an affordable broadband infrastructure can be provided in Europe. A key requirement is for network technology that can be upgraded on an incremental basis, for the provision of bi-directional broadband services as and when required. The explosion in demand for telecoms capacity over the last decade precipitated the move towards establishing fibre connections to the home (FTTH) to provide an all-optical connection path. This offers virtually unlimited bandwidth to the user and removes the bottlenecks, which hamper existing infrastructure. Only homes connected in this way will be able to fully exploit all possibilities of the Information Society. However direct fibre connections are still too expensive for most users. The response has been to explore ways of delivering enhanced bandwidth over the existing copper access infrastructure. New approaches and principles were successfully developed in ACTS projects BROADBANDLOOP, TOBASCO, PRISMA, FRANS, PLANET and COBNET.

One solution is to use the existing telephone plant as the basis for an overlay of Passive Optical Networks. These are installed as far as the building or the street cabinet, and utilise the existing copper pairs from the telephone infrastructure for the final connection. The street cabinet houses some equipment to convert the signals from optical to electric modulation. Trials in ACTS used Very-high-speed Digital Subscriber Line (VDSL) modems and demonstrate great potential future high-bandwidth services.

Other highly compact systems, offer competitive low-cost alternatives and were successfully implemented as part of the ACTS projects. These include a symmetric VDSL variant capable of operating over a distance of 1000m at bit rates up to 26Mbit/s. Since in most EU countries the average distance between the street cabinet and the customers premises is around 1000m, this approach to provide broadband access over existing copper plant could be successfully

implemented almost everywhere. As a major step towards this long-term goal the PLANET Project developed an all-optical network demonstrator capable of serving 2000 homes with up to 2.4 Gbit/s of bandwidth. The results of this project clearly demonstrated the superior capabilities of optical connectivity. In most EU countries a coaxial cable delivers cable-TV services, and can also be used to deliver broadband services. In conjunction with a commercial cable operator the TOBASCO project, ran a trial with customers connected by their standard TV cables to an optical network. The hardware, transmission protocols and the network management system allowed up to 40 customers to be connected. Wavelength multiplexing allowed the connection of 16 ONUs on a single fibre, giving a potential of 640 customers per fibre.

3.3.1.8 Optical Switching

Optical switching is a key prerequisite for future optical networks. Work covers R&D on optical switching and interconnection, experimental evaluation, including optical switching fabrics for use in wavelength routing, and architectures for parallel optical interconnections inside and between equipment. *PLATO* has developed high speed flexible optical-interconnect systems and novel, low cost switching elements. *REPEAT* addresses a broad range of technologies for 3R regenerators (re-amplification, reshaping and re-timing).

LOIS aims at the integration and interconnection technologies for building large photonic space switches. *APEX* develops advanced semiconductor based photonic integrated circuits for optical cross-connects.

3.3.1.9 Ultrafast Connections

Solitions are stable short pulses of light which travel unchanged over enormous distances on optical fibres. They offer the potential of ultrafast communications, 1000 times faster than with other traditional light modulation techniques. The potential of Soliton-based techniques to boost transport network capacity have been successfully investigated in the ACTS research programme. During its field trial in Jönköping, Sweden, the MIDAS project established a World Record for soliton transmission of 80Gb/s over a single channel in an operational network, over a distance of more than 400 km. Together with the achievements from the other two projects, ESTHER and UPGRADE, it is evident that the work on Soliton technology in ACTS developed essential concepts for future global photonic communications systems.

Different implementation scenarios for soliton systems have been investigated by the ESTHER, MIDAS and UPGRADE projects. Non-linear effects and polarisation-mode dispersion in optical fibres impose strict limitations in high capacity fibre transmission links. Bit-rates of 100'sGb/s can be achieved by aggregation of a very large number of channels each of 2.5 Gbit/s. This alleviates substantially the problems related to non-linearities, but results in a more complex and costly high-

capacity systems. An alternative of increasing electrical modulation speeds by 16 times was demonstrated by SPEED and HIGHWAY projects. They not only showed the theoretical feasibility but also demonstrated in real environment conditions the practicality and robustness of their approach.

3.3.1.10 Optical Building Blocks

Recent Developments in optical amplification, passive optical devices, or increases in laser output power have now enabled optical fibre networks to reach cost parity with traditional copper cable for new residential installations. A range of options for providing broadband access for residential and small business customers was investigated further in the ACTS programme. Results indicate that the optimum choice in any particular case is dictated as much by historical, geographical, economic and regulatory factors as by purely technical considerations. Cost comparisons between different technologies are complicated by the fact that it is not possible to accurately forecast equipment costs for future high volumes, however it is clear that the cost per connection for fibre technology is decreasing steadily. Recent technological advances (in RACE and ACTS) have moved key building blocks such as optical amplifiers and WDM transmitters from development to products. New Silica-on-silicon integrated optics technology (CAPITAL), advanced components and modules (BLISS) (OSC), optical fibre amplifiers (FAST) and control of widely tuneable lasers (ACTUAL) have been explored.

The VERTICAL project demonstrated the high-speed operation of new laser technologies, whilst PHOTOS project successfully investigated the role of photosensitive fibre in emerging component systems, pushing towards consensus across a number of key areas.

3.3.1.11 Towards a Global Photonic Infrastructure

Optical transmission systems have gradually evolved from simple bit pipes interconnecting two locations into highly sophisticated networked infrastructures. These transmission infrastructures form part of the global telecommunications network and therefore need to interwork with existing equipment and protocols. The ACTS research programme identified the need for a harmonized approach to interworking and network management. Network management concepts developed by PELICAN, MOON, MEPHISTO, METON, UPGRADE, and DEMON build on existing principals and adapt and enhance them for optical networks. For example, improved quality of service has been achieved using the enhanced traffic-protection mechanisms, developed by the ACTS Project MEPHISTO, in the multinational field trial of PELICAN.

During 1998 the partners of these projects made over 100 major contributions to the European Telecommunications Standards Institute (ETSI) and the International Telecoms Union (ITU). These contributions, released as ITU

standards, lay the foundation for global interworking of photonic networks, and will have a world-wide impact.

3.3.1.12 A Roadmap for the future

In May 1998, representatives from many of the leading telecoms operators, equipment manufacturers and universities in Europe and delegations from the US, Canada, and Japan met in Brussels at a one day symposium to launch "roadmap" for optical communications R&D in Europe over the next 10 years. This was put together by members of a pan-European collaboration co-ordinating and disseminating information among the 33 photonics projects in ACTS. It highlights key areas for European R&D in the evolution of photonic networks, including interworking between different physical media and network protocols, optical transparency and network management, monitoring and protection. Network performance and require quality (QoS) are particularly important issues, given the potential information loss resulting from a simple link failure. At component level, the Roadmap encourages R&D focus on a variety of optical components: all-optical 3R-regeneration (REPEAT) and emerging novel devices. The report concludes that 2010 will see broadband services delivered by fibre to the home in tandem with a WDM optical transport layer. Migration paths to an all-optical future will naturally differ from operator to operator, and from country to country, however Photonic technologies will prove a cost-effective, future proof, technically superior solution to improve network performance to the levels required by both commercial and domestic demand.

3.3.2 High Speed Networking Area

Advanced communications infrastructure are the foundation of the Information Society; with high-speed networking being the key to cope with the explosive growth of the Internet and the demands of future mobile and multimedia services.

3.3.2.1 World leadership in ATM

In this area, the ACTS Programme supported the largest experimental ATM (Asynchronous Transfer Mode) network in the world: it linked prototype networks in most EU member states, later extending via satellites and submarine cables to connect up with similar networks around the world. Eighteen major European network operators worked together. The resulting JAMES network was the culmination of more than ten years of work in European collaborative research.

This initiative secured the development of the ATM technology; provided a basis on which to implement convergence with the IP (Internet Protocol) world, and validated the technologies.

3.3.2.2 Developing the ATM technology

The JAMES and QUANTUM ATM networks tested the interoperability and capabilities of ATM features and provided Trans-European connections for a large number of other ACTS projects trials. These trials thoroughly tested the service and technology aspects of the delivery platforms.

These networks were extended to the rest of the world, and experiments on them created a basis for collaboration between researchers in the EU and in Central and Eastern Europe in the use of common technologies and standards.

The ‘Global 360’ initiative in 1997 and 1998 was one of the most visible demonstrations of global broadband communications. Major international conferences in Brussels, Madeira, Calgary and Moscow were linked for several days. In addition, participants joined the events from European Russia, Siberia and Canada. Seventeen sites were involved and communications between 16 of them were fully symmetric, with full audio and video participation.

3.3.2.3 Including satellite links.

The GAMMA project extended the experiments by connecting the network to Japan with an INTELSAT link. The trial demonstrated clearly that a high quality intercontinental ATM could be established over heterogeneous networks including a satellite link. A later trial with European and Japanese Satellite Agencies demonstrated image and file retrieval from Japanese satellite catalogues using Internet browsers and file transfer software. The VANTAGE project also demonstrated that ATM networks can include satellite links and that ATM switching is a viable long-term option.

3.3.2.4 Intelligent Networks and Services

A prototype Broadband Intelligent Network was developed by the INSIGNIA project. It involved four different types of ATM connections to Broadband Service Switching Points. This allowed inter-operation with narrow band Services, demonstrating the interworking at the network signaling level. It established performance models for Broadband Intelligent Networks. WATT offered an information service on the European ATM network testbeds, using mainly the EXPERT testbed, and supported a number of ACTS projects field trials. During the trials, users could remotely monitor on-line the experiments as they were happening. The trial data was also recorded and structured for further use for off-line demonstrations and courses.

3.3.2.5 Applications in Finance, Education and Industry

Modern capital markets require efficient telecommunications to exchange orders and distribute market information from Stock Exchanges all over Europe.

THESEUS project developed a financial terminal meeting thesis demands and built and validated the main components of an innovative ATM-based system. The concepts were validated in trials carried out with the JAMES network between

Paris and Brussels, and between Rome and Paris with the VANTAGE satellite ATM network. In October ‘95 students from the International School in Basel and the Glashan High School in Ottawa started to work together, using ACTS broadband communications. The first "Virtual Classroom" event took place in May 1996, and has now become a permanent fixture in the schools’ calendars. Coverage of the events has been shown on the local Ottawa TV station. The event was presented at the "Second Conference on Global Lifelong Learning" organised in March '97.

The DIVINE project developed a high-quality, multi-point video-conferencing system compliant with new international standards (ITU-T H.323), and tested it in industrial environments. The system allows multi-point video-conferences across any ATM network or switched LAN, without the need for a Multi-point Control Unit. It has also been used to encourage children aged 6 to 10 to use new communications. Advanced design and testing of cars and aeroplanes involves close collaboration between specialised designers and equipment in many different places. MULTICUBE showed how advanced high-speed networks could bring these teams together for seamless co-operative work. MULTICUBE provided facilities for IP multicast over ATM multicast hardware. This infrastructure allowed the users’ high-speed LANs to be interconnected. Over 200 hours of trials were carried out.

3.3.2.6 Protecting Networks

The PANEL project disentangled the complexity of multi-layer faults to improve the reliability of networks. It compared the operator’s reliability requirements with the capabilities of protection technologies, and identified which layer should deal with a particular type of fault. This prevents management systems in different layers from initiating counterproductive actions in response to a fault.

The REFORM project addressed network operations and management; from physical layer operation to service and business management. It specified, designed and realised a system for making ATM networks resilient to changing mixes of traffic, topologies and services with different QoS requirements. The system was based on international standards, and field trials were conducted with commercial ATM switches on the ACTS EXPERT testbed in Basel, Switzerland, and ATM networks in Norway, Greece and Japan.

3.3.2.7 ATLAS - a Single Chip ATM Switch

The ASICCOM project has designed and built a high-performance switch, with a low cost of "input queuing", with per Virtual Circuit queuing and weighted "round-robin" scheduling. This ATLAS-I single chip incorporates a 16x16 ATM switch, with point-to-point serial links running at 622Mbps (and even 1.25, 2.5 or 5.0 Gbit/s when ports are bundled). The chip is manufactured in 0.35 mm CMOS

technology. A 1.5 Gbit/s serial-link transceiver also paves the way to more highly integrated ATM switches and components

3.3.2.8 Broadband to the Home

The introduction of broadband communications and multimedia services on existing networks is a major challenge for telecommunications and cable TV network operators. The ATHOC project evaluated options and carried out field trials. The results contribute significantly to the development of fast Internet access systems.

In conjunction with this, the BONAPARTE project developed and tested an ATM Passive Optical Network (PON) and demonstrated its capabilities with telemedicine and teleteaching applications. Public teleteaching courses were held in 1996 and 1997 and telemedicine users have held routine clinical sessions since November 1997 The ITUNET project combined fibre feeding from small geographical cells with VDSL/ADSL used on the last drop to the customer premises. Network investment can be tuned to demand for broadband services and offer access at up to 25-50 Mb/s to the majority of today's subscribers. This offers traditional network operators a cost-effective way of providing high quality interactive multimedia services to every household.

3.3.2.9 Charging for ATM

Charging has always been an important issue for providers and users of telecommunications services. While ATM supports voice, data, video etc, with an appropriate Quality of Service, it costs little more to provide the 'gold-plated' service than the 'bargain-basement' service. However, if everyone selects the 'gold-plated' service, the network will soon overload and extra capacity will have to be deployed. ATM charging schemes must therefore to offer customers an incentive to choose the quality of service needed by their applications. In ACTS, three complementary approaches were investigated:

The CA$HMAN project demonstrated charging schemes and accounting management in an operational environment. The user-network interface issues and the use of intelligent agent software were investigated. This approach was based on sound economic principles and can be extended to Internet charging.

The CANCAN project focused on the application of accounting and customer care, and the development of a "connection details record". The project developed charging models, for billing systems for ATM services. It compared different charging schemes, and successfully tested prototypes.

The SUSIE project established the basis for "Premium IP convergence charging" for various levels of quality of service for multimedia communication services on Internet protocols over ATM and in a standard network management framework (TMN).

3.3.2.10 Integration of Internet and ATM

Multimedia applications guaranteed quality of service rather than today's Internet 'best effort' approach. The ATM system can guarantee quality while handling different types of traffic on the same backbone. However, there are various ways to handle the integration of IP and ATM: The DIANA project has studied four schemes for providing quality of service for Internet applications with test cases for comparing the schemes. One innovation allowed flexible integration of IP and ATM environments. The interworking between the two environments could be modified as required. These developments were all LINUX-based.

The ELISA project combined Internet service architectures with ATM network technology to design scaleable service architecture. It showed that the Internet and ATM can provide multimedia services in two scenarios: an Integrated Service (IntServ), and the Differentiated Services (DiffServ). Video conferencing was used to demonstrate how these can offer quality of service guarantees and flexibility.

The PETERPAN project explored how to use ATM to support quality-sensitive Internet applications by enabling the IP layer to exploit the standard reservation, traffic control and signalling capabilities of the ATM transport layer. The EXPERT project developed a concept to allow ATM-attached hosts to set up end-to-end IP for the exclusive use by the specified applications. This allows the critical applications to benefit in a straightforward way from ATM's inherent ability to guarantee the quality of service. The AROMA project demonstrated the addition of quality of service guarantees to legacy TCP/IP networks and their use to deliver broadband services to the home over cable networks.

The IthACI project focused on advanced IP switches for ATM networks, demonstrating the applicability and the interoperability of different IP switching techniques. It has also enhanced these techniques for Multicast, Quality-of-Service, Resource Management and Mobility.

3.3.2.11 Combining ATM with "next generation Internet"

The BTI project deployed IPv6, the new generation Internet Protocol, with extensions to multicast. It interconnected with ATM connections and various access network technologies. The COIAS project designed a global Internet infrastructure using IPv6 over ATM and DVB satellite networks. This platform is one of the first IPv6 based networks in Europe and its results will have significant impact within and outside Europe. COIAS has showed how to optimize the choice of the communications path by including alternate routing mechanisms depending of the required quality of service.

3.3.2.12 Guidelines for Interoperability in Networks and ATM deployment

The GINA project has established consensus and developed guidelines for network interoperability and ATM deployment. The guidelines not only reflect the

latest findings and results of ACTS trials, but also take note of worldwide trends in Network Interoperability ATM. They will be of wide value to telecommunications network operators, computer vendors, corporate users, services providers, regulators, and policymakers.

3.3.2.13 The Overall Impacts

The results of projects have been consolidated into European Standards whenever appropriate. The ACTS projects themselves participated actively to this process, and collectively made significant contributions to ETSI, ITU-T, ATM Forum, OMG, TINA, IETF, ISO, and the FSAN (Full Service Access Network) initiative. The RTD has also successfully demonstrated the value of broadband networks. The convergence of technologies has evolved from an ATM to an IP centric approach. In that context, the ACTS High-Speed Networking work has:

§ Raised awareness: acting as a reference for the provision of information to existing and new potential broadband users.

§ Promoted experiments on new advanced networking technologies based on ATM and IP.

§ Fostered network usage: working closely with research projects, end-users and local access providers to facilitate access to and use of the broadband networks in a manner that will support and encourage joint experiments and demonstration of advanced high-speed services and applications.

§ Developed next generation technologies: by integrating IP and ATM technologies to place ATM as a core broadband component in full synergy with the diffusion of IP technologies.

3.3.3 Mobility and personal communications networks Area

The growth in mobile telephone services over the last five years has been phenomenal. In 1998 the sales of digital cellular phones outpaced those of Personal Computers and by 1999, three times more Europeans used mobile phones than PCs. It is estimated that in Europe there will be one mobile phone for every four people by the year 2000 and the global market for mobile services will be in the range of 150 billion €. ACTS RTD has now laid the foundations for the next Universal Mobile Tele-communications System (UMTS), a 3 rd generation of mobile systems, which will provide mobile services anywhere, at any time and at affordable prices. UMTS will support multimedia services and Internet access from remote areas, the car, the home, the boat and the aeroplane. In addition, ACTS projects have developed novel technologies to reduce power consumption and improve the efficiency of mobile systems. These include neural networks, superconducting components and software radio. Trials have demonstrated the

value of mobile and wireless networks for residential customers, the disabled, the construction and entertainment industries, emergency services and tourism.

3.3.3.1 Universal Mobile Telecommunications System

Following the outstanding commercial success of GSM (Global Systems for Mobile Communications), ACTS projects have defined a Universal Mobile Telecommunications System (UMTS) as part of the 3 rd generation of global mobile systems. It will integrate terrestrial and satellite networks to provide high quality, high bandwidth mobile interactive multimedia services anywhere at anytime. The ITU Workplan for global standards and the ETSI Workplan for European UMTS are both on target for complete standards by the year 200, with the first operational systems by 2002.

3.3.3.2 Mobile Systems - The Next Generation

ACTS projects have defined a modular and 'future proof' network where current and future radio access systems can be made interchangeable. This UMTS architectural model separates the parts, which depend on radio technology from those which do not. It allows a smooth transition from second generation access technologies (GSM and DECT) to innovative third generation radio access systems. The RAINBOW project confirmed that this model strikes a balance between flexibility and complexity; and between innovation and migration requirements. Successful demonstrations have involved a variety of access techniques, together with a wide range of applications in public high- and low-density and business environments.

3.3.3.3 The transition from GSM to UMTS

The transition from 2nd to 3rd generation systems calls for careful planning as mistakes could be very expensive. The EXODUS project has clarified a smooth migration path: by demonstrating terminal and personal mobility for voice, data, and image applications; and defining, implementing and demonstrating the Intelligent Network functionality needed to evolve from 2nd to 3rd generation mobile systems and for extensions to ATM-based mobility management

3.3.3.4 Radio Interfaces

3G mobile radio systems will have to support a wide range of services from at data rates from 144 kbps up to 2 Mbps in indoor and picocell environments. The FRAMES project implemented a radio interface which validates the ETSI UMTS Terrestrial Radio Access (UTRA) specifications. Five candidate technologies were considered. In January 1998, ETSI chose a concept which combined W-CDMA with TD-CDMA operation in the unpaired part of the spectrum. ETSI has submitted this UTRA concept to ITU-R for IMT-2000 using evaluation data from FRAMES. Project partners have also contributed to US and Japanese standards activities.

3.3.3.5 Wireless Networks for the Home and Office

Wireless networks are easier to install than cables. The MEDIAN project developed and tested technology for a high speed wireless LAN using 60 GHz Monolithic Microwave Integrated Circuits, VLSI technologies and an ATM interface. The subsystems were integrated into a network suitable for use in an office or home, and were successfully tested in joint trials with other ACTS projects. The AWACS project validated broadband ATM wireless links operating at 40 GHz, through a trial of a virtual office for location-independent working of designers and production facilities. The WAND project demonstrated wireless ATM access, with bit-rates up to 34Mb/s, that could support low mobility terminals over a range of 100m. The work also addressed 'IP over ATM' with guaranteed Quality of Service. The results have confirmed that broadband wireless access will be a mass market product within the next five years. Business users of mobile services will have full access to broadband interactive multimedia services in the near future thanks to the groundbreaking SAMBA project. It produced the world's first system implementing all the main broadband cellular network functions. It also developed portable mobile terminals incorporating 40 GHz transceivers and antennas. Two applications were demonstrated at EXPO'98 in Lisbon, Portugal.

3.3.3.6 Supporting the Disabled with Mobile Communications

The UMPTIDUMPTI project has shown how current and future mobile communications services could be used to help people with various kinds of disabilities. Working closely with disabled people, the project defined user requirements for mobile handsets, portable digital assistants and applications to enhance the quality of life of various types of handicapped user and improve healthcare. The design recommendations will make services easier for everybody to use. The projects' results have been welcomed by special needs support groups, such as the Information Societies Disabilities Challenge (IsdaC), as an important contribution to using technology for empowering disabled people.

3.3.3.7 Mobile Electronic Commerce

Soon it will be possible to do business anywhere and at any time, using fixed or mobile terminals to access multimedia information services. The MOMENTS project has developing a wireless media highway for distributing multimedia to mobile terminals. The system used a unique way of presenting graphical information, integrating animation, 2D graphics and 3D graphics into a "scene graph" to access information over the WEB. The project developed service packages, which it used to demonstrate the commercial viability of mobile multimedia in a three phase trial involving over 100 users for several months. The information about users' behaviour patterns, expectations and experiences of new services are now being used to develop business plans for commercial services.

3.3.3.8 Third generation services

ACTS projects have developed a clearer understanding of what users and service providers might expect from UMTS applications. This will accelerate the take-up and use of mobile multimedia services over UMTS and will encourage the adoption of the mobile-API (Application Programme Interface) by the computer industry, application and service developers and standards bodies. OnTheMove seamlessly integrated different bearers, carriers and terminal types. It developed a Mobile Application Support Environment (MASE) and a Mobile-API for mobile devices. The main focus was on the transmission of images and animation data. The concepts were validated in a 'City Guide' service, enabling maps to be downloaded according to the location of the user. The MOVE project enhanced the MASE architecture to handle the integration of real-time data. Its Voice-Enabled system supports mobile multimedia applications with Voice over IP. It allows design of voice and data applications over an Internet connection independent of the technology of the underlying networks. It was validated by a hotel search application for mobile customers. The first public demonstration was given early in 1999 and further demonstrations are planned for the Mobile Summit 99 (Sorrento), and Telecom 99 (Geneva).

3.3.3.9 Smart Antennas

Adaptive antennas can increase transmission capacity. The TSUNAMI-II project developed algorithms for beam-forming and beam-steering, which track the user to maximise the signal or minimise interference. Hardware was designed and evaluated for both RF and baseband applications. The results of trials demonstrated clearly that smart antenna technology is feasible and cost-effective for third generation mobile systems such as UMTS. The SUNBEAM project developed innovative base station array processing architectures and algorithms for UMTS that are sufficiently flexible to support a range of different second and 3G air-interface standards. A field trial demonstrated that this technology can improve the performance, increase the flexibility and reduce the cost of deploying software radio, next generation base stations and other networked wireless services.

3.3.3.10 Software Radio

Future radio sets will be so versatile that you will not need to buy a new one each time a new service or feature is introduced. They will obviously have some hardware inside but will be controlled by software. This can easily be changed to add new features. The radio can be very small and consume much less power than today's radio. Technology for these 'super-radios' was developed by the SORT and FIRST projects. It offers an economic way of providing flexible, modular, multiband and multimode radio systems which complement the UMTS Radio Access Network (URAN) of 3rd generation mobile systems. Trials have helped to refine the concept of software radio to the point where it can be

exploited commercially in Europe's next generation of satellite and mobile systems.

3.3.3.11 Superconducting radio transceivers

The SUCOMS project has explored how High Temperature Superconductors could make it possible to design smaller, yet higher-performance, radio equipment. Superconducting circuits offer increased sensitivity, lower losses and reduced noise, allowing hand held terminals to operate at lower power, increasing battery life and reducing RF radiation. Unfortunately, even high temperature superconductors need to be cooled, and the challenge is to build a fridge that uses less power than the superconducting circuitry saves. The SUCOMS project demonstrated a cooling system that allows superconducting components to be used in base stations, with guaranteed maintenance free operation for at least 3 years. The results offer the prospect of cheaper and more efficient base stations. They also offer users the prospect of terminals with longer lasting batteries and reduced radio emissions.

3.3.3.12 Neural networks

Neural networks are linked arrays of microprocessors and memories that mimic the human brain's ability to learn from experience. NEWTEST used them to correct channel distortions and interference on a satellite link. The approach outperformed traditional techniques, especially when complicated modulation schemes were used. Results of simulator test will significantly reduce the cost of commercial terminals for future S-UMTS services.

3.3.3.13 European Interactive Satellite Systems

ACTS projects have investigated how a new generation of broadband satellites could provide services to both fixed and mobile systems. The SECOM project has defined the system elements and developed the related technologies for future Mobile Broadband Satellite Systems. The system can provide a wide range of services to urban users and to difficult environments. It was the first project in Europe to support broadband mobile service using the Ka and EHF bands. The demonstration led to a remarkable level of interest from the industry. The target system has been adopted by ITU-R as the reference standard model for SSOMS (Satellite System offering Multiple Service). The EuroSkyWay initiative has adopted many SECOMS ideas and its results have influenced other National and global initiatives. The system was demonstrated at the 1999 Bologna Show, the ACTS 99 Mobile Summit in Sorrento, Air Expo in Paris, Telecom 99 in Geneva and the 5 th Ka-band utilisation conference.

3.3.3.14 Switches in Space

The ASSET project has validated the EuroSkyWay approach to on-board satellite switching for broadband traffic. The validation involved a comprehensive end-to-

end system demonstrator, which tested the complete set of communication layers and the cumulative effects on both fixed and mobile channels. The results of ASSET mean that Ka band broadbandsatellite services could be on offer in Europe by 2002.

3.3.3.15 Integrating Satellites into 3rd Generation Mobile Systems

The project SINUS developed and evaluated a novel way of integrating satellites into UMTS. The approach used W-CDMA and the system performance was validated in a variety of environments and field trials. These demonstrated hand-over between satellite and terrestrial links, together with other important features, such as mobility management, call routing and resource management. The results pave the way for delivering seamless and ubiquitous services to both business and residential customers.

3.3.3.16 Multimedia Services Over Satellite

There is growing interest in using advanced satellite technology to deliver multimedia services. Many systems have been proposed and claims have been staked for spectrum allocations. The WISDOM project has defined a baseline design; demonstrated it with a sophisticated end-to-end test bed, and contributed to future standards for satellite multimedia services. The design includes an ATM switch for switching between high-gain antenna spot beams and inter-satellite links and offers ATM access to users.

3.3.3.17 Ubiquitous Communications

The vision of mobile services to anyone, at any place and anytime can only be achieved cost-effectively by using satellites in different earth orbits. The SUMO project brought together all the components for a complete UMTS system. The testbed included terrestrial radio access and an ATM-based core network in order to demonstrate S-UMTS interoperability with end-to-end interactive multimedia services. It successfully demonstrated the UMTS access concept, showed how to deliver Bandwidth-on-Demand services and how to adapt applications to different mobile networks. The SUMO testbed was demonstrated at the ACTS'99 Mobile Summit '99.

3.3.3.18 Mobile Multimedia via Satellite

UMTS will provide access to communications services via terrestrial radio systems and fixed networks. It will also have a satellite component (S-UMTS), using geostationary and low earth orbit satellites to deliver multimedia services to customers in remote areas or on ships and aeroplanes. The TOMAS project exploited the synergy between work in ACTS and international space organisations, such as the European Space Agency and Inmarsat, to involve real groups of end-users in various demonstrations.

3.3.3.19 Dissemination activities

The ASAP project has publicised and promoted the results of ACTS mobile projects by means of a book and companion CD-ROMs. These present the achievements of the largest co-ordinated group of mobile communications research projects in the world. The project has organised the ACTS 1999 Mobile Summit, together with a series of roundtables and discussion groups addressing key issues in the industrial world. The Mobile Summit conferences have become major events in the diaries of engineers around the world and show clearly how the ACTS programme has driven the global development of mobile communications.

3.3.4 Service Engineering, Security and Communications Management (Areas 5 and 6)

3.3.4.1 General

Advances in computer hardware and software technologies over the last ten years are truly breathtaking. Telecommunications relies more and more on computers and intelligent software for administration, management, control, interoperability between different systems and administrators etc. The future Global Information Infrastructure will be even more dependent on distributed computing to provide efficient management and generate attractive applications and services in an ever growing competitive market, where reduced time scales for the development of new and sophisticated services are of paramount importance. ACTS projects in these two Areas developed and validated open frameworks for the provision of communication services, based upon the most up-to-date technology paradigms (object orientation, distributed processing, agents, etc.). Special attention was devoted to the development and promotion of open architectures for service brokerage. The work of ACTS also encompassed the application of such paradigms in the deployment of open architectures and services to different businesses (e.g. brokerage architectures). ACTS also successfully contributed to provide validated technology necessary to enable effective end-to-end management of networks and services in a multi-provider, heterogeneous network environment towards the vision of ubiquitous personalized communications services irrespective of the network technology). The broad topic of security, addressed in a number of projects throughout ACTS, led to significant results applicable to both fixed and mobile networks, thus contributing for the definition of a comprehensive sphere of secured personal communications.

3.3.4.2 Service Engineering

Europe pioneered the work on Open Service Architecture (OSA) and ACTS played a crucial role in validating solutions for the faster evolution towards an

open market for advanced telecommunication services. The impacts of ACTS work on TINA (Telecommunication Information Networking Architecture) initiative as well as in the architectural work carried by OMG was considerable. A large number of "technology trials" has been carried out with the objective of validating open specifications and common best practices recommendations (a number of them recorded in the SIA chain documents and/or adopted in defacto standard bodies).

3.3.4.3 Open Service Architectures

ACTS projects validated - through multiple services implemented, enhanced and prototyped Open Services Architectures based on OMG/CORBA principles. ACTS projects created the basic sets of reusable components (objects) necessary to quickly, flexibly and safely construct communication services. The VITAL and the DOLMEN projects were instrumental in this respect. They extended the Open Service Architecture framework to support multimedia, multiparty, discrete terminal mobility, personal mobility, fixed/mobile service integration, IN like supplementary services and service management. Both projects promoted transnational trials to demonstrate prototype systems developed according to these new architectural paradigms and were recognized as world leaders in applying these new concepts.

3.3.4.5 Middleware

The set of open distributed processing software required to support the execution of services is usually, known as "middleware". The key project was RETINA, which developed a TINA compliant Distributed and Real Time Processing Environment (DPE) based on CORBA. The results are at industry-quality level, overcoming some of the traditional shortcomes of distributed system products - scalability, adaptability, quality of service and performance. ACTRANS focused on one key component of the middleware, namely the Open Distributed Transaction Processing (ODTP). The ACTRANS Toolkit was successfully trailed and promoted in industry through the Open Group, a major dedicated cross-industry body.

3.3.4.6 Methods and Tools

Future telecommunication requires enhanced processes, methods, tools and development support environments. Rapid service creation is recognized as a key requirement for the business opportunities offered by networks providing component based services. Projects SCREEN and TOSCA developed open service creation platforms which could be used in the generation of services on CORBA, TINA or IN based architectures. Successful demonstrations included exposure of the creation environments to business consultants, telecom managers as well as service designers and developers.

3.3.4.7 Open Brokerage Architecture

The concept of broker, capable of acting on behalf of a customer in guiding the selection of the most suitable service has long been well known. To ensure an open market place for brokerage services and their clients (customers and service providers), ACTS projects developed and validated an open brokerage architecture incorporating the most recent interworking standards. The projects contributing actively were ABS, COBRA and OSM. Beyond the use of specific technologies (such as X500 protocols for Directory Services or WHOIS++ for federation of Directories), all these projects realised their brokerage systems on open distributed environments (e.g. based on CORBA or DCE) and involved real users. Projects addressing these topics strongly supported the GAS chain, having actively influenced standard bodies like OMG Electronic Commerce Task Force and EWOS and entities like EUROCOMMERCE or COMMERCENET.

3.3.4.8 Advanced (Brokerage) Services

Trials of pre-commercial pilot services were a feature of most ACTS projects. Project PRINT-IT addressed distributed print services while MULTIMEDIATOR validated a brokerage service supporting customers and suppliers of publishing services. Project EIES focused on the access to inter-harbour information system while project TECODIS addressed collaborative teleworking applied to software development. AVANTI focused on the means to provide access to services for people with special needs. Some of the projects that focus on architectural issues also developed significant prototype services

3.3.4.9 Secure Architectures for Electronic Commerce

A number of projects contributed to the definition, development and validation of open architectures for secure electronic commerce. In particular, the project SEMPER focused on the provision of multiparty security for the full spectrum of electronic commerce actors interested in promoting secure electronic commerce over insecure networks. The results of this project support in an integrated way public key security services such as digital signatures, certification and credentials, contract signing, electronic payment and fair exchange. In order to ensure openness and platform independence, the APIs are specified and implemented in JAVA. The open generic architecture developed was made available for public review and evaluated by extensive trials involving real users.

3.3.4.10 Fixed and Mobile Convergence

Fixed and Mobile Convergence is concerned with the provision of network and service capabilities which are independent of the access techniques. A shared objective of the related ACTS projects was to ensure a common architectural approach for mobile and fixed services, reason why EXODUS addressed IN features for UMTS and enhancements to B-ISDN to provide mobility services, whilst from a longer term perspective, DOLMEN and VITAL addressed a common service architecture applicable to both fixed and mobile networks. Extensive trials

have been carried out, by the co-operation between e.g. EXODUS, COBUCO and RAINBOW, projects that developed UMTS related demonstrators and by the demonstration of security features (project ASPECT) in the EXODUS testbed.

3.3.4.11 Securing Personal Communication

The 1establishment of secure environments for communications was a major focus of the ACTS program. A number of projects worked on complementary topics such as IPR protection (e.g. image authentication through digital image signature or labelling) and security mechanisms (e.g. secure provision of services in a mobile environment including payment issues and the use of TTP (trusted third parties). Projects like ASPECT focused on investigating, implementing, testing and providing solutions for fraud detection in future mobile networks (UMTS), TTP for end-to-end security services in UMTS, advanced capabilities for User Identification Modules (UIM) and secure billing. Further to the work of ASPECT, USECA developed, implemented and validated a complete and viable UMTS security architecture. SCARAB evaluated and demonstrated the use of smart cards as a universal token for seamless and secure access to a multitude of telecommunication services.

3.3.4.12 Securing ATM Networks

Instead of implementing security services at the application level, an alternative studied by ACTS was securing the communication on a network connection basis, thus ensuring a far-reaching independence from the application. SCAN approached confidentiality in ATM networks by means of symmetrical DES, Triple DES encryption with 56 and 112 bits effective key length respectively. The results show negligible additional delays, not affecting delay-sensitive applications.

3.3.4.13 Integration of Security and Safety

The development of harmonised frameworks and methodologies increases the social confidence in the reliability, safety and security of systems and services. SQUALE contributed to increase the awareness of the two separate security and safety communities about common approach towards dependability.

3.3.4.14 Communications Management

In the context of the open service market environment created by liberalization, the development of effective telecommunications management is essential to ensure that the equal usage and supply provisions of ONP are met. ACTS projects focused on the management of multidomain environment (being a domain related to a particular network technology or ownership). MISA developed and prototyped, at Pan European level, integrated management of ATM and SDH networks. PROSPECT provided validated solutions to the design and implementation of management systems for large co-operative applications (e.g.

tele teaching). The project TRUMPET concentrated in the provision of integrity mechanisms for end-to-end connections across multiple management domains.

The project FLOWTHRU successfully demonstrated the integration of re-usable components from several other projects in ACTS (e.g. REFORM, PROSPECT, VITAL, MISA and TRUMPET) by building management systems supporting the flow of information across different organizational and technological domains. The significant contribution of the ACTS-Management projects to the works of TMF, TMN and TINA is today broadly recognised.

3.3.4.15 Agents

Today, the agent paradigm and the emerging agent technologies are considered key for the implementation of flexible and scalable solutions for an open service market within the Information Society. In particular they are an important design paradigm for providing intelligence on demand (e.g. Mobile Agents), enabling advance co-operation and autonomous behavior of distributed network components (e.g. Intelligent Agents) or inter-operating highly dynamic and heterogeneous open, distributed systems. Mobile and intelligent agents, although different in their origins, emphasis, implementation and application platforms, will be essential components of the future ACTIVE Networks. ACTS pioneered the application of the agents paradigm to telecommunications. A cluster of 16 agent related projects has been created (CLIMATE - cluster for Intelligent Mobile Agents for Telecommunications Environment) and successfully influenced the agent community world-wide developing new concepts, prototyping agent based systems applied to multiple business sectors, influencing the two most powerful standardisation bodies FIPA (Foundations for Intelligent Physical Agents) and OMG MASIF (Mobile Agent System Interoperability Facility), co-operating with Eurescom, and even influencing the emergence of enhanced platforms in the market (e.g. Grasshopper)

3.3.4.16 Agent Platforms

Multiple agent platforms were used (e.g. Objectspace Voyager, IKV++ Grasshopper, IBM aglets, Mitsubishi Concordia, General Magic Odissey) in the different projects. The projects MIAMI, FACTS and MARINE promoted amongst other things, extensive comparison of the characteristics of such platforms, contributing to their enhancement.

3.3.4.17 Agents supporting IN and Mobility

A number of projects (AMASE, CAMELEON, MARINER, MONTAGE and SCARAB) focused on the extension of existing IN and mobile architectures, including mobile devices and smart cards, by introducing mobile and intelligent agent platforms. They developed and tested new ubiquitous applications, including video-on-demand, UMTS virtual home environment, customer profile management, mobility support, financial services and dynamic provider selection.

3.3.4.18 Agents supporting Communication Management

Projects such as MIAMI, IMPACT, FACTS, MARINER and MONTAGE successfully addressed the challenges of decentralised management, made possible by the use of agents and the adoption of "management on location" techniques. These projects focused with significant success in areas such as IN/SS7 load control, connection admission control for ATM networks, accounting and charging services for fixed and mobile environments and service reservation.

3.3.4.19 Agents supporting end-to-end systems

Projects in ACTS also addressed agent software design that concentrated in "end-systems" rather than in the communications network. Projects such as OCEANS, ABROSE, DICEMAN, MODEST and OSM+ analysed selected design topics in relation to agent negotiation, knowledge representation and human-to-agent interaction. Prototypes validated the design solutions proposed.

3.3.4.20 Integrating Results

ACTS forstered information exchange and promoted co-operation between projects exhibiting adequate degree of commonalities. The broad aspects of architectures, service creation, management and security are strongly inter-related. Projects DIFFERENCE and DOLPHIN promoted coherence between the approaches followed by projects in different topics, ensuring at the same time that ACTS results were appropriate to industrial usage by establishing close links to industrial Fora (e.g. OMG, TINA, EURESCOM, ETSI, DAVIC, TMF, etc.).

4. ESPRIT High Performance Computing and Networking (HPCN)

4.1 OBJECTIVES

The objective of the domain is to help all sectors of industry exploit the opportunities offered by advanced computing and networking systems to add higher levels of intelligence, reach larger throughputs, reduce costs or ensure shorter response times in their products, processes or services. All activities are driven by user requirements and oriented towards development of concrete applications and later marketing of added value in products or services. They are leading to results at various levels - from the applications themselves, through systems and sub-systems, to architectures and platforms.

The domain addresses "HPCN at large". Applications exploit parallel systems, distributed and heterogeneous infrastructures, high performance workstation or PC clusters and heterogeneous architectures with multiple processors.

Advanced networking services have become an integral part of these systems and infrastructures, enabling both interactive uses of remote resources and concurrent activities in geographically dispersed locations.

4.2 R&D and PST activities

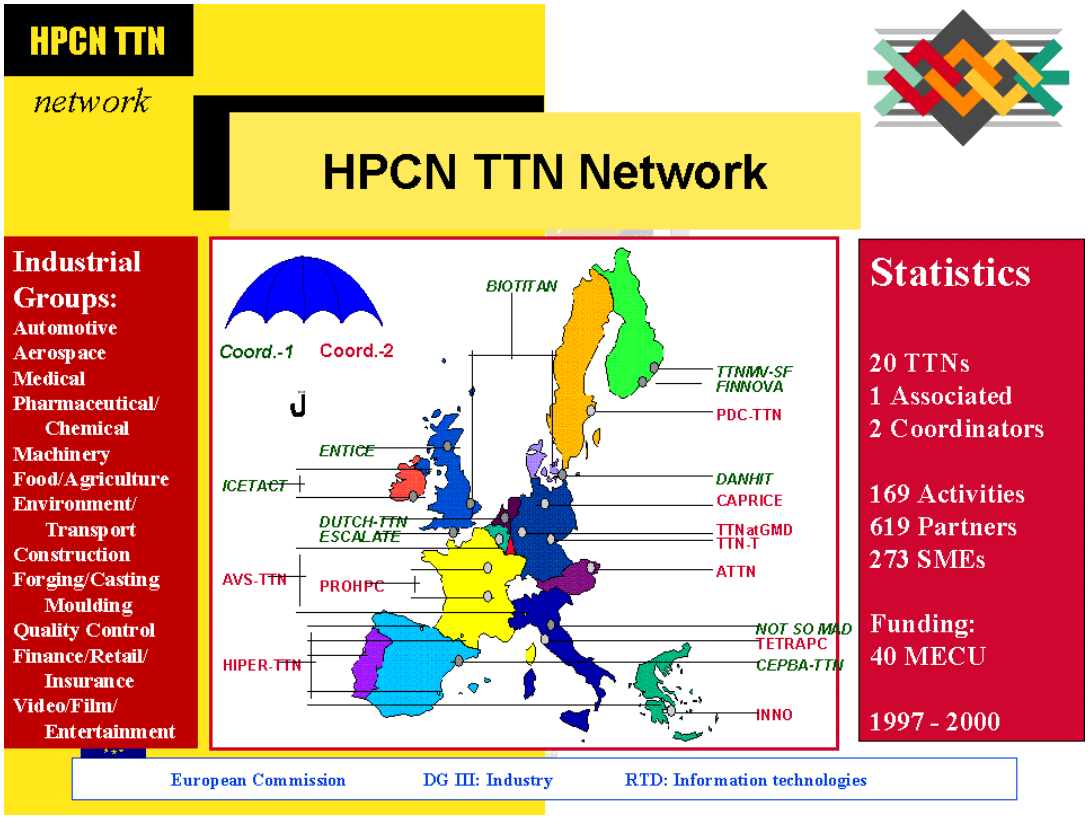
ESPRIT HPCN supports integrated activities, with 80% of the resources devoted to R&D projects and the remaining 20% for take-up actions.

The areas covered include compute and/or data-intensive applications as well as the supporting technologies and infrastructures. These are grouped into seven domains. Three application areas covered from the start of the program are Simulation, Embedded Systems and Information management and Decision Support Systems. Two supporting technology areas were identified as Multi-Site Networked Applications and Development and Execution Environments. These were complemented with two new areas in 1998: R&D for Humanitarian Demining applications and Research Networking infrastructure and services.

At the end of 1998, a large majority of the projects are still running. On average, two third of the participants are industrial organizations, half of which are SMEs.

An HPCN take-up network was set up in 1997 with the objective of improving industrial competitiveness through the promotion of HPCN across a wide range of industries. This initiative specifically targets smaller organizations, which can now afford powerful low-cost systems made out of commodity components. The more widespread adoption of this technology will have significant implications for

industrial competitiveness with resultant economic benefits. The network counts 20 centres across Europe and aims at encouraging new users to adopt HPCN technology. The activities of these centres, called Technology Transfer Nodes (TTNs) includes co-ordinating groups of take-up activities, demonstrations at industrial conferences, dissemination of publicity material, organization of seminars and workshops and publication of magazine and journal articles. 169 demonstrator activities involving 619 organizations of which 273 are SMEs are underway, and results are becoming available for wider industrial exploitation in a large variety of industrial sectors.

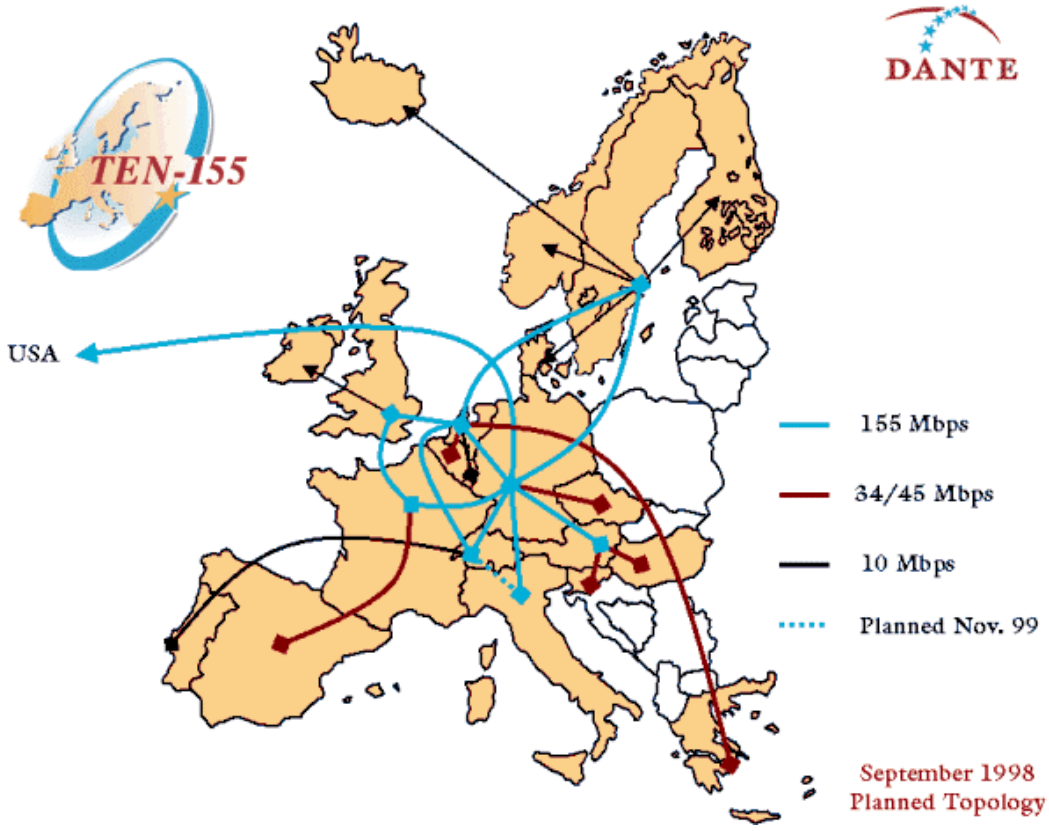


(source: “ESPRIT HPCN activities” 1998 report , Agnes Bradier”)

4.3 Activities in Research Networking

The usage of communication networks (Internet) has changed the way research is done. It is making science more collaborative and distance independent, allowing for efficient sharing of information and knowledge, and accelerating the access, dissemination and production of results. As a consequence, research networking has now become an indispensable tool for European research activities across all research disciplines.

It is for this reason that National governments invest in computer research networks to meet the needs for effective communications of national RTD institutions. As the international dimension of most research domains is increasingly important, the European Commission is providing support to ensure that the European interconnection of the national research networks can meet the users' requirements for capacity, connectivity and quality of service.



(source: “ESPRIT HPCN activities” 1998 report , Agnes Bradier”)

Following the TEN34 project launched in 1996, the QUANTUM project has been launched as a transition between Framework Programme IV and Framework Programme V. The project is co-funded by the three R&D Programmes in Information and Communication Technologies - Esprit, ACTS and Telematics - and by the National Research Networks. QUANTUM provides the capability to interconnect the national research networks at high speed by supporting a new core network, TEN-155. It interconnects nodes in Austria, France, Germany, Italy, the Netherlands, Sweden, Switzerland and the UK at 155 Mbit/s. Belgium, the Czech Republic, Greece, Hungary, Slovenia and Spain will be connected to the core at 34/45 Mbit/s. There will be 10 Mbit/s links to Luxembourg and Portugal. The design of the TEN-155 network also provides for extension of the service to the USA and other Continents.

The new research network will combine the best from both IP and ATM technology and will offer guaranteed Quality of Service using ATM technology in addition to a ‘best efforts’ IP service. A development programme will test advanced IP and ATM technology in a Wide Area and International environment with a view to implementing the results at a later stage. Consequently, the TEN-155 network will meet the requirements of the European research community for more bandwidth and guaranteed Quality of Service to facilitate international communication and co-operation test-beds.

Migration from the current European research network TEN-34 to the new TEN-155 network started autumn 1998.

4.4 SELECTED ACHIEVEMENTS

Although it is still premature to evaluate the global impact of the HPCN domain in Framework Programme IV, significant trends and indications of achievement can be deduced from the first results of R&D results and take-up actions.

During this period of work the application domains extended from engineering and technical applications to commercial and citizen oriented application. In addition to traditional sectors of HPCN applications such as Aerospace, Automotive, Mechanics, Civil Engineers, Metal Forming and Chemicals, HPCN is also becoming a mainstream technology in Finance, Insurance, Retail, Food Industry, Medical Equipment, Education and Training and Entertainment. The advent of Internet and web based computing is facilitating the access to HPCN solutions at affordable cost.

4.4.1 HPCN: Simulation

Simulation is playing an increasingly crucial role in the design of new and better products as well as in the optimization of production processes. Simulations need to be accurate and often requires massive amount of computation. Multi-physics phenomena, multi-scale phenomena (that is phenomena where extremely different time or space scales play a role) and design optimization are among the most compute- and data- intensive problems of current industrial interest.

The success of simulation and the consequent proliferation of simulation tools have made more and more urgent the need for both tool interoperability and reusability and for integrated environments enabling collaboration of geographically distributed multidisciplinary teams.

Although traditionally emerging from engineering applications, simulation is more recently developing into a generic technology forming an integral part of the

complete value chain ranging from design over manufacturing to marketing, sales and support in all industrial and services sectors.

Some significant results are listed hereafter.

EP 20189 PROMENVIR (HPC-based PRObalistic Mechanical DesigN ENVIRonment) has produced the first software environment for performing Computational Probabilistic Mechanics in a distributed environment. It enables to quantify the degree of reliability of a mechanical system through the treatment of the uncertainty of its structural parameters, loads and boundary conditions. It has a considerable commercial success with European and North American car manufacturers. It is expected that it may influence the way in which car crash certification requirements shall be placed in the future.

EP 22691 SEEDS provides a distributed interactive simulation system for ground traffic in airports. The system provides guidance and control of all aircraft and ground vehicles on the movement area of an aerodrome. It can be used both as decision-support tool for the design and optimization of ground control and also as a training tool for airport controllers. It replies to a strong need since ground traffic in airports is becoming more and more the true bottleneck for air traffic capacity.

In the domain of computational chemistry, the EP 22685 MESODYN has delivered a modelling package which combines innovative new physics and multiprocessor systems so that users like BASF (D) can simulate entirely new applications in process, petroleum, pharmaceutical and consumer product industries

EP 20248 CLOVIS and EP 22745 INDEX have developed advanced visualisation techniques, which enables the practical handling and visualisation of the large volume of data resulting from complex simulations. Interestingly, these intra-internet based visualisation technologies, originally developed for/by aerospace and car industry (Aérospatiale, British Aerospace and BMW) are being transferred to new application areas such as the medical imaging and telemedecine applications by European hospitals.

4.4.2 HPCN embedded systems.

The objectives of this area are to promote the use of high-performance computing and networking in embedded applications, through the demonstration of their added value in a wide range of products and processes. This also includes the development and use of high-level design tools and of reusable subsystems using standard interfaces.

Successful applications have been demonstrated in industry sectors as diverse as media, post, electricity, water, steel, mail order, and medical systems. A significant trend of growth is shown in the processing of video and 3-D data. Products

already on the market as a result of our actions include integrated systems in products and processes and also subsystems and development environments.

A very important step was made in the application of ultrasound in medical imaging as a result of Project 21073 3D ULTRA, showing real-time 3-D images of babies in the mother's womb. Kretztechnik of Austria launched an interactive system for 3-D ultrasound imaging now already a market success. The DigiGlobe award from Deutsche Telekom and FOCUS was awarded to Fraunhofer Gesellchaft, technical co-ordinator of the project, for this achievement. The ceremony took place under the patronage of Commissioner Martin Bangemann.

The main objective of the EPSIS project (23483) is to enhance the applicability of the EPSIS system for real-time substitution of commercials in TV images of sports events, which is increasingly successful worldwide. Also in this project, Partner DVS developed add-on boards to process real-time video images on PC's and low-end workstations. These are now being commercialised in part through an OEM agreement with Sun Microsystems. The company turnover increased 70% in the last year.

In Project 21036 EIVIS, Dassault Electronique developed a prototype complete in-flight entertainment system for commercial airliners and demonstrated it at Le Bourget 1997 and ASEAN Aerospace 1998. Partner Becker Avionic Systems is announcing new sound-system servers for commercial airliners and video player and video server products for business jets and luxury cars.

The CATIE project has developed inspection systems using high- speed colour cameras in the application areas of food sorting, steel inspection, parquet and wood grading. In particular, the food sorting system to be manufactured and exploited by Elexso for coffee beans has received very good response when tested at industrial sites in South America. The system is well positioned for the current and future market evolution.

The EUROPRO project has integrated high speed interconnect components (Gbit link from Bull), and software development, modelling and monitoring tools, to provide a powerful and modular platform for real-time data and signal processing. This architecture is the basis of the next generation of systems developed by major industries such as Thomson and Gec-Marconi in domains like, radar, sonar, and communications.

4.4.3 HPCN: Networked Multi-Site Applications

Projects experimenting in real scale applications of advanced networking services enabled to build confidence in distributed application between geographically dispersed locations. Initially starting best practice application experiments, the first projects oriented toward collaborative working using video conferencing and shared workplaces enabled to develop a better understanding of new ways of working, electronic commerce and virtual mobility. New project trends toward distributed interactive simulation, and large-scale collaboration test-beds are paving the way to future activities in Framework Programme V.

As a consequence of the CANET project RENAULT is for example, deploying broadband corporate networks to introduce concurrent engineering in the workplace, and Siemens Automotive is currently organising a joint venture with automotive equipment manufacturers for collaborative activities using concurrent engineering. The European automotive industry is developing collectively the foundation of a European automotive extranet.

The COVAS project, among others, enabled the trial of COVISE, a collaborative visualisation and simulation environment, in a real industrial environment. The success resulted in the confidence to establish a spin-off company, Vircinity IT GmbH, that markets the product and services based on it.

An interesting result from the project MSC is the demonstration carried out by 13 Schools from Spain and The Netherlands who worked in collaboration on an educational project on environmental issues; pollution, weather forecast, etc. Indeed, young children under 12 could prove that remote manipulation of HPCN technologies such as high speed networks, parallel computers and simulation algorithms do not require necessarily sophisticated technological expertise.

After intensive experiments of remote simulation in the RCNET project, Reverse Engineering Ltd, an engineering consultancy firm has acquired enough expertise to decide to open remote offices. Their engineers based in the USA will be able to use advanced networking technologies to exploit remotely the facilities and expertise based in the UK in a very effective manner.

4.4.4 HPCN: Development and Execution Environments

Development Environments have been evolving along two major tracks: the building of integrated environments combining all functionalities of the design and deployment process to improve usability and applications performance on a wide range of platforms, and the development of tools for cost-effective access to, and concurrent sharing of applications. Main achievements include clustering and distribution techniques for heterogeneous environments in local or geographically

dispersed locations as well as systems for web-based access to data- and/or compute-intensive applications. In Execution Environments, R&D projects have focussed on chip design for fast interconnects (e.g. SCI technology and SCI/PCI interfaces), efficient data storage, system integration combining fast interconnects with off-the-shelf computing nodes to build affordable high performance computing platforms for mainstream applications.

Commercial exploitation of first results have started with products and services introduced on the market.

PatTENT MPI is a commercial product from Genias (D), resulting from the collaboration with University of Coimbra (P) in the ongoing WINPAR EP 23516 project. It enables MPI based parallel applications to run efficiently on low-cost platforms built from networks of PC's. It is internationally agreed to be the best functional and performing environment when compared to competitors.

Vampir is the market leader in MPI performance analysis tools. It is sold by Pallas (D). The product benefited from several projects including project PHAROS. The original version of Vampir is in active use at a variety of sites worldwide: Research Labs, Universities and hardware vendors.

In the projects SISCI and PACHA, the company Dolphin (N) developed a new generation of connection systems based on SCI chips and interface boards. This has enabled the company Scali (N), as system integrator, to deliver top range performing platforms to their customers for very low-cost since it is based on clusters of PCs.

The MICA and PHASE projects have developed and tested pilot services accessing remotely through a web interface computing resources and applications. These range from fluid dynamics for furnace or building design, to molecular modelling for drug design. In ADELFI and CONTENT, mutli-tier architectures are used for building web-based services for visualisation and data exploration in medical, banking, genetics and engineering applications.

EUROSTORE is exploring how to move very large data objects between high performance computers, workstation clusters, and storage libraries at speeds many times faster than is possible with today's software systems. QSW, a leading company in High Performance Computers, is the driving force of the project that also involves demanding users such as DESY and CERN.

4.4.5 The HPCN TTN Network

The HPCN TTN Network aims at introducing the benefits of HPCN to SMEs especially in new application areas. The first results coming from the network are very encouraging to this respect. The following examples show the widespread applicability of HPCN technologies in new areas like entertainment, health and culture.

SIMON from the Finnish TTN has demonstrated the industrial use of a new imaging technique called spectral imaging. The system has been installed in a Finnish brewery and is used for sorting crates. This new on line sorting system has increased the line capacity, and the monthly savings are more than 50.000 ECU. The technology can easily be used in other application areas such as quality inspection of tiles.

MOODS from the Italian TTN is an integrated system of computer-based lecterns which can be used for co-operative editing and visualisation of music for large orchestras. Having been demonstrated at Teatro alla Scala in Milano, it has the potential to better manage and use musical scores during rehearsals and performances with significant cost reductions. The new technology was interpreted as a major step of the musical sector into the information age.

PSUDO from the Irish TTN has demonstrated how computer simulation can be used to determine how a drug is released in the human body, directly benefiting patients (and society) that can then be prescribed a precise dosage for a better treatment.

CAREN from the Dutch TTN is an interactive Computer Assisted Rehabilitation Environment based on HPCN virtual reality technology. It will be applied in areas of physiotherapy, orthopaedics, and neurology to help patients to overcome their balance disorders. It has also promising potential for application in other domains such as ergonomics, architecture, sports, etc.

A significant part of our cultural heritage is stored on old film stocks that until now have been beyond repair using classical techniques. The FRAME project from the Austrian TTN has demonstrated how to cost effectively use HPCN techniques in order to preserve the contents of old film, using digital technology.

5. Information Society Technologies (IST)

5.1 General

Information Society technologies projects are still under execution, while the first ones must have been ended in the end of 2000.

The convergence of Information Society technologies and markets is leading to new products and services that are increasingly transforming our lives. Examples may be seen in the emergence of appliances for accessing both interactive and broadcasting services and in the development of intelligent home and office environments that provide users with easier and any-where access to services. The impact of IST on every-day's activity is also raising people's expectations for a better quality of life. As technology is becoming part of our normal surroundings, new tools for content creation and diffusion provide individuals with powerful means to express ideas and develop their creativity for professional use or for leisure.

The rapid deployment of e-commerce and the expansion of mobile and global access to services are driving enterprises to continuously modify their business models. They can build on advances in technology such as component-based development and platform independence, better to master and integrate their value chains. While this provides greater flexibility and allows them to react instantly to changing market needs, it also induces considerable shifts in working modes and structures.

Underlying these advances is the development of a multipurpose computing, broadcasting and communications infrastructure. In the last two years, Internet and mobile systems have been driving development in the field. The move towards closer integration between internet-based, and fixed and mobile technologies as well as progress in middle-ware and multi-tier architectures are paving the way for the realisation of a global distributed and shared infrastructure. RTD is leading to improved authentication techniques and more dependable systems. Ensuring higher confidence in the technology and the related infrastructure is an essential condition for participation of citizens in the Information Society.

The above developments are setting the scene for a further expansion of the Information Society into an era where the technology will be all around us but almost invisible and where networked devices embedded in commonplace appliances enable people to have easier interactions with services.

5.2 KEY ACTION I - SYSTEMS AND SERVICES FOR THE CITIZEN

The aim of this work is to foster the creation of the next generation of user-friendly, dependable, cost-effective and interoperable general-interest services, meeting user demands for flexible access, for everybody, from anywhere, at any time. Work, including the associated education and training, encompasses RTD addressing the whole of the Key Action, as well as specific RTD in the following fields: health; special needs (including ageing and disability); administrations, environment; transport and tourism. Certain of the ubiquitous issues addressed throughout the whole of this program will be taken up further in order to pay due consideration to the needs and expectations of the typical users in this Key Action, in particular the usability and acceptability of new services, including the security and privacy of information and the socio-economic and ethical aspects.

5.3 KEY ACTION II - NEW METHODS OF WORK AND ELECTRONIC COMMERCE

The aim of this work is to develop information society technologies to enable European workers and enterprises, in particular SMEs, to increase their competitiveness in the global marketplace, whilst at the same time improving the quality of the individual's working life, through the use of information society technologies to provide the flexibility to be free from many existing constraints on both working methods and organisation, including those imposed by distance and time. Specific attention will be paid to the social implications of new working methods, in particular their impact on equal opportunities and quality of life. It covers both the development and the trading of goods and services, in particular in the electronic marketplace, and takes into account the different requirements and capabilities of the individual worker, consumer and of businesses and organisations, and includes the related training. Considerations of the global context, in particular the rapid evolution of the marketplace, and socio-economic factors will guide the work, and the objective will be to develop and demonstrate world-best work and business practices, exploiting European strengths such as electronic payments, smart cards, mobile systems, software for business process modelling and enterprise management and consumer protection

5.4 KEY ACTION III - MULTIMEDIA CONTENT AND TOOLS

The aim of this work is to improve the functionality, usability and acceptability of future information products and services, to enable linguistic and cultural diversity and contribute to the valorization and exploitation of Europe's cultural patrimony, to stimulate creativity, and to enhance education and training systems for lifelong learning. Work will cover new models, methods, technologies and systems for creating, processing, managing, networking, accessing and exploiting digital

content, including audio-visual content. An important research dimension will be new socio-economic and technological models for representing information, knowledge and know-how. The work will address both applications-oriented research, focusing on publishing, audio-visual, culture and education and training and generic research in language and content technologies for all applications areas, and will include validation, take-up, concertation and standards.

5.5 KEY ACTION IV: ESSENTIAL TECHNOLOGIES AND INFRASTRUCTURES

The aim of this work is to promote excellence in the technologies, which are crucial to the Information Society, to accelerate their take-up and broaden their field of application. The work will address the convergence of information processing, communications and networking technologies and infrastructures. The focus will be on technologies and infrastructures common to several applications, while those specific to one application only would be addressed in the context of that application in other parts of the Framework Programme.

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Resources for the mentioned projects where taken from the above urls

Project name	***URL***
DVBIRD	http://www.infowin.org
EIES	http://www.expertel.fr/EIES
EMERALD	http://www.tid.es/trabajo/emerald/bienvenida.html
EMPHASIS	http://www.fzi.de/esm/projects/emphasis/new/welcome.html
EPRIWATCH	http://www.epri.org
ETD	http://www.eto.org.uk
EURORIM	http://www.swt.iao.fhg.de/eurorim
EXODUS	http://www.italtel.it/drsc/exodus/exodus.htm
FAIR	http://www.databank.it/dbc/fair
FRAMES	http://www.de.infowin.org/ACTS/RUS/PROJECTS/FRAMES

GAIA	http://www.syspace.co.uk/GAIA/
GAMMA	http://www.estec.esa.nl/gamma/gamma.htm
IBCoBN	http://www.ibcobn.nssl.co.uk
IMMP	http://www-nrc.nokia.com/immp
INFOBRIDGE	http://www.infowin.org
INFOWIN	http://www.infowin.org
INSIGNIA	http://www.fokus.gmd.de/research/cc/cats/projects/insignia/
INTERACT	http://www.itc.co.uk/interact
KIMSAC	http://www.broadcom.ie/kimsac
MICC	http://www.iao.fhg.de/miks3
MIDSTEP	http://www.INFOWIN
MIRAGE	http://www.itc.co.uk/mirage
MISA	http://www.misa.ch
MOMENTS	http://veppi.mm.wdss.ntc.nokia.com/
MOON	http://www.uk.infowin.org/ACTS/RUS/PROJECTS/ac231.htm
MULTI-MEDIATOR	http://www.ac.upc.es/multimediator
MULTICUBE	http://www.cselt.it/sonah/MULTICUBE/
MUSIST	http://www.swt.iao.fhg.de/swt/projects/musist
NEWTEST	http://www.enseeiht.fr/newtest
NICE	http://www.berkom.de/nice
On The Move	http://www.sics.se/~onthemove
OPTIMUM	http://www.fou.telenor.no/optimum/
OSM	http://www.osm.net
PANEL	http://www.intec.rug.ac.be/research/projects/panel/
AMUSE	http://www.italtel.it/drsc/amuse/amuse.htm
ASICCOM	http://www.intracom.gr/asiccom
ASPECT	http://www.esat.kuleuven.ac.be/cosic/aspect/
ATHOC	http://www.athoc.de
ATLANTIC	http://www.bbc.co.uk/atlantic
ATMAN	http://www.cselt.it
AURORA	http://www.ina.fr/Recherche/Aurora/index.en.html
AVANTI	http://avanti-acts.org
AWACS	http://www.cselt.stet.it/sonah/AWACS/index.html
BONAPARTE	http://analysys.co.uk/acts/bonaparte
BOURBON	http://www.lake.ie/bourbon
CA$HMAN	http://www.isoft.intranet.gr/cashman/
CABSINET	http://www.fub.it/cabsinet/home.htm
CANCAN	http://www.teltec.dcu.ie/cancan