NEC Laboratories Europe

Innovative Solutions for a Converging IT and Communications Environment

NEC Central Research Laboratories

NEC Central Research Laboratories (CRL) is the innovation engine that makes NEC world leading provider of technology innovations. By its research program CRL is pursuing two principal goals: (1) the creation of new basic technologies for future businesses, and (2) the early exploitation of novel technologies to significantly advance its current business.

NEC Central Research Laboratories is focusing on three main areas:

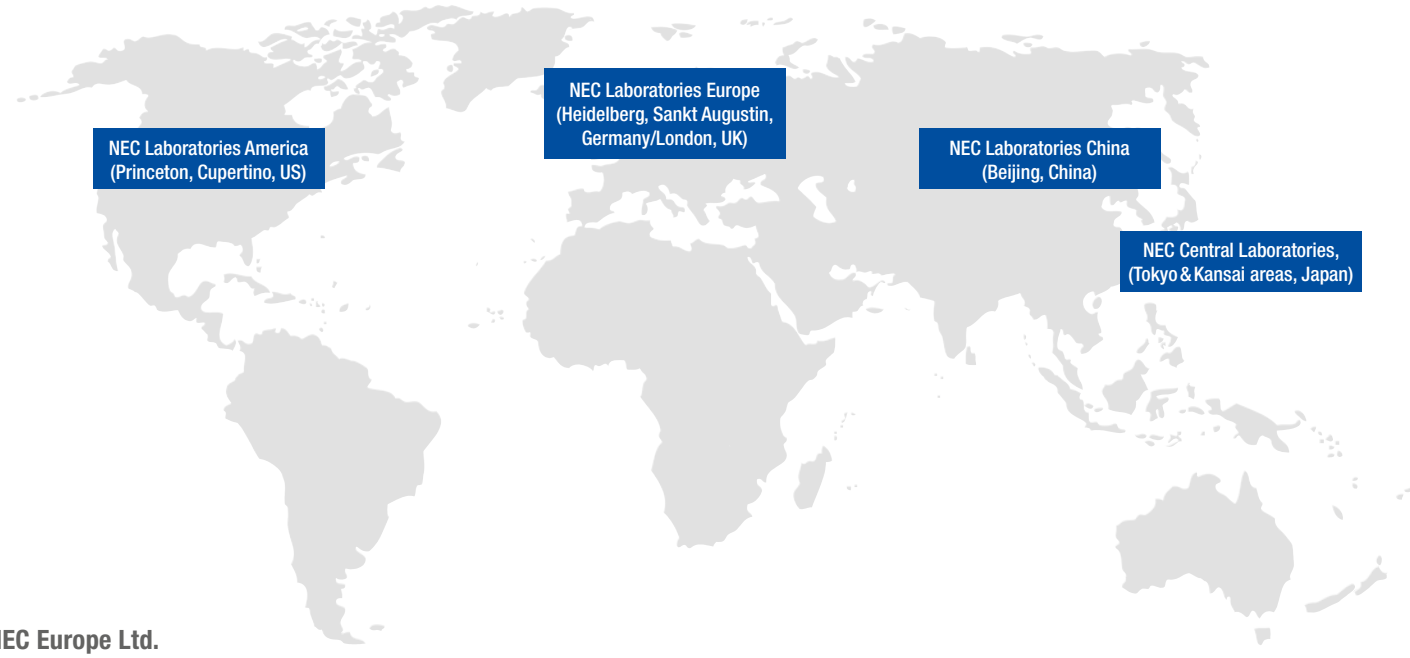
- Solution Platforms Research
- IT/Network System Platforms Research
- Materials and Process Research

Key to NEC Central Research Laboratories' mission is the invention of new technologies documented by a growing patent portfolio.

In order to transfer creativity into marketable innovations, CRL works closely with NEC's product development units to create new products or to enhance existing products with new technologies.

NEC's R&D achievements span a wide range of areas from carbon nanotubes over a highly reliable, low-cost next generation Grid storage architecture called HYDRAstor to speech recognition technologies.

Besides six research and development facilities in Japan, with more than 1500 staff members, NEC Central Research Laboratories maintains six facilities in Europe, China and the US, with some 300 staff members.



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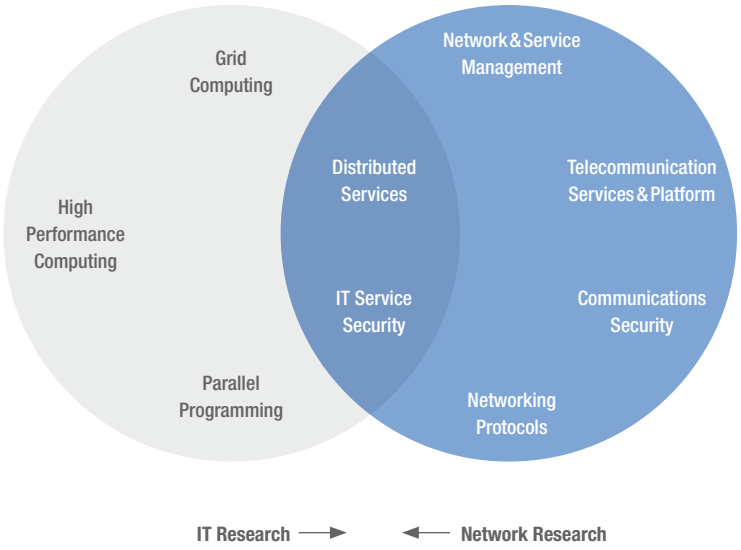
Research for a Converging IT and Networks Environment

For over 10 years, NEC has been active in its European laboratories in research and development of IT and network technologies. The focus of the laboratories has been software-oriented research, reflecting the needs and the strengths of the European market. Over the years, technology trends have changed incredibly. For the last few years the convergence of technologies and markets has been a key driver. Today every network node is a programmable IT system and basically every IT system is connected to one or more networks, i.e. it is part of the universal Internet. As a consequence of the rapid convergence of IT and telecommunications technologies and markets, NEC Europe in June 2007 merged its two research laboratories into the new **NEC Laboratories Europe (NLE)** consisting of an IT Research Division in Sankt Augustin, Germany, and a Network Research Division in Heidelberg, Germany, and London, UK. NLE has grown during the last decade to well over 100 staff members.

Whereas the two divisions continue to follow individual research agendas in the areas of future communications architectures and protocols, in parallel programming, and high-performance computing and applications, the divisions join forces in the areas of distributed services, service platforms and security and privacy. Through the combination of expertise in the distributed services area, NLE is taking a leading role in this area of rapidly growing importance.

A corner stone in NLE activities has been the open collaboration in European and German research programs and the close collaboration with NEC business units, in order to transfer research ideas and prototypes into products, i.e. to turn creativity into innovation. Over the years the research divisions have participated in well over twenty European research projects in close collaborations with IT vendors, network operators, service providers, user groups and research institutes. NLE staff members are recognized as profound contributors to research projects, conferences and professional organizations.



An important mechanism in the transfer of research results into future products is standardization. In the telecommunications segment in particular, standardization is a major step on the road from new research ideas to marketable (and interoperable) innovations. Therefore, it is not surprising that a large number of NLE-researchers actively contribute to international standardization activities.

In the telecommunication industry the Internet has become the all-encompassing communications platform. However, the Internet of today is not the same as the Internet of a decade ago. Although many improvements have been made since the time of the first emails and file transfers, we only now begin to realize the immense possibilities that the Internet may offer in the future. Huge challenges are inherent in the integration of mobile and ubiquitous devices such as sensors with personal, multi-media and mission critical communications. Europe, America and Asia today all have large ongoing research programs to create the next generation Internet that will support pervasive communication services in a reliable and manageable way.

On the enterprise side, industry is increasingly using distributed, collaborative environments – e.g. for product design and development – to enhance efficiency and to allow interaction between companies and academic groups possessing specialized expertise and resources.

Networked service-oriented systems, including provision of Software as a Service (SaaS) allows enterprises to focus on their core competences and service providers to deliver added-value solutions easily and efficiently.

While the IT/networking revolution implies the need for software systems to manage interacting, distributed IT services on the one-hand, it results on the other hand in a growth of the requirements for computing capabilities in IT systems deployed at all levels: mobile devices, desk-top systems, home-electronics, departmental servers, data centers and specialized high-end computer centers and supercomputers. When the environmental aspect, e.g. power efficiency, is taken into account, it quickly becomes clear there is only one possible approach: parallel processing. What was once the reserved domain of “Big Science” becomes a pervasive technology in the future ICT landscape!

The following sections give an introduction to major research topics addressed by NLE.

Network Research Division – Advancing the Limits of Communications Networks and Services

Communication for Life

When the Network Research Division in Heidelberg was founded in 1997, IP communication was already an important issue in business life. Since then, ubiquitous communication services have invaded most aspects of our daily life. Yet it appears that this is just the beginning of a trend that will continue to significantly change our society.

Society itself is changing rapidly and so are the challenges and questions confronting researchers. As a consequence, research programs are morphing: from just providing new means of communication, towards integrating communication into everybody's life in ways reflecting social trends, such as the aging society, the patch-work family and the nomadic work force.

Combination of Services Makes the Difference

Integration of services into business and private life requires a level of flexibility that exceeds by far yesterday's service capabilities. Today we do not think in terms of individual services, but rather about how to combine multiple services easily, how to customize them quickly, and which basic service components will make future services more useful and more convenient. Services of the future should adapt to the user and contribute to his or her own content, offer personalization, adapt to context, and be available whenever and wherever they are needed.

Common Network Platform: The Internet

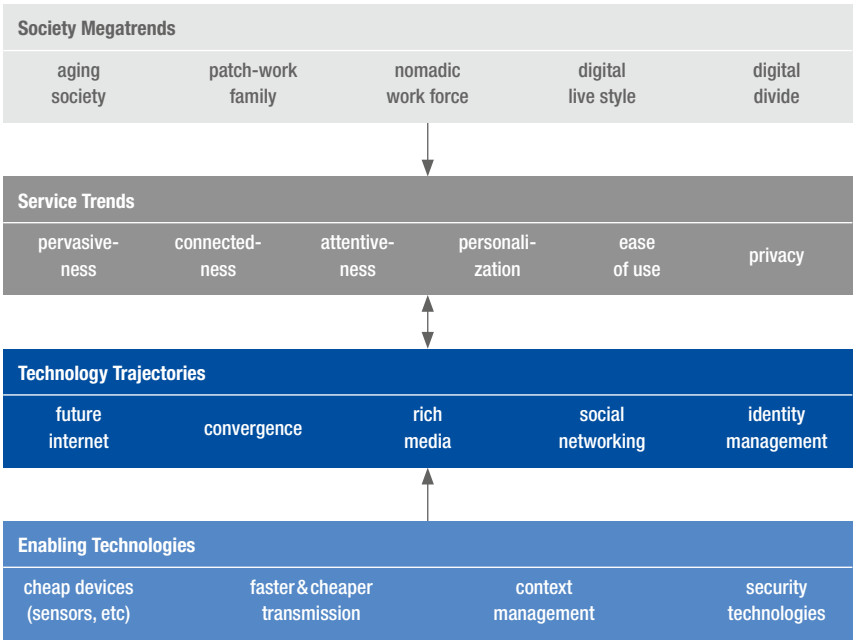
For the provisioning of the envisioned multitude of services at affordable cost, a cheap and reliable common platform is required. The Internet has the main characteristics to fulfill the requirements of this common platform in the best possible way. The Internet is on the move to replace and incorporate many competing network technologies, such as ISDN, ATM, and many others. At the same time, the Internet has several limitations that appear to be difficult to overcome without changing it fundamentally. Consequently, Internet-related research at NLE Network Research Division follows two aims. On the one hand we try to solve shortcomings of today's Internet concerning security, mobility, and quality of service by developing and standardizing extensions of the current Internet. On the other hand we investigate new technologies that might one day have the potential to replace the current Internet.

Top-Level Research Requires Intensive Collaboration

Since its foundation in 1997, the Network Research Division has matured to a highly respected scientific and professional partner in European research. Today its staff members publish in the most relevant journals, act as chairs of leading worldwide conferences and serve as invited speakers at R&D events. The Network Research Division follows an open approach to frontline research by intensive collaboration in joint projects with universities, telecom-operators and manufacturers. Many collaborative projects are co-funded by the Framework Programs for Research and Technology Development of the European Union.

Integrating Research, Standardization and Development

With an integrated approach to research, standardization and development the Network Research Division ensures a continuous stream of new product ideas. The Division considers early standardization key to market success and encourages staff with excellent technical skills and a good understanding of emerging technologies and market trends to contribute to standardization bodies. In this way, the Network Research Division receives valuable feedback on its own ideas and technologies, before they are transferred into products, and helps NEC to build worldwide solutions aligned with latest advances. By conducting market research in Europe and by supporting technical marketing of NEC projects, the Network Research Division acquires deeper understanding of customer needs and can focus activities accordingly.



Matching society megatrends and enabling technologies

Investigating New Network Technologies

Networks and Communication will become Commodity

The Internet and cellular/wireless networks have become commonplace. Soon half of the world's population will have mobile phones, and Internet access is no longer a privilege. Communications in the 20th century was between people, however communication in the 21st century will be for users and objects, including sensors of all kind. Convergence in various dimensions is needed: fixed with mobile, unicast with multicast and broadcast, the Internet with cellular and wireless. Voice will become Voice over IP and TV will become IPTV. NLE targets a dynamic infrastructure that securely provides ubiquitous access to mobile users over increasingly diversified heterogeneous technologies.

The Future of the Internet

NLE investigates novel communication paradigms and network architectures for Next Generation Networks (NGNs) and the Future Internet (Post IP). In frontline research projects NLE investigates technologies with the potential to overcome shortcomings of the current Internet, either as add-ons or as replacements. Topics of investigation include new routing and addressing techniques for global core networks as well as for local wireless mesh networks. Another important aspect of future networks is self-management, enabling autonomic networks to (re-)configure themselves and adapt to environmental changes.

Car-2-Car Communications

NLE expects communication networks of the future to extend to cars, to enhance drivers' safety and to provide convenience and entertainment applications inside vehicles. NLE has developed a core communication platform in collaboration with major European car manufacturers. The platform has been widely used for trials in national and European projects. Key to the platform is NLE's "position-based routing" technology, which has been integrated with the general Internet infrastructure and which NEC and strong partners will make the basis of enhanced safety and communication in tomorrow's cars.

Wireless Sensor Networks

As the next wave beyond RFID technology, Wireless Sensor Networks will significantly impact our lives, generating completely new business opportunities. NLE is developing medium- and large-scale wireless sensor networks with particular emphasis on integrating comprehensive security capabilities from the very beginning. Such security is essential for the acceptance of sensor network technology. NLE is provisioning a complete tool box of security aware components to enable the rapid development of trusted sensor network applications.

Peer-to-Peer Communication

Peer-to-Peer applications have already entered the communications world as end-user applications for file sharing and Internet telephony. NLE also uses peer-to-peer technology for enriching traditional services, such as TV, with user-generated content. For end-users creating their own live TV programs, more capabilities and more flexibility is required in broadband access networks. NLE is developing network technologies for operator-supported high quality peer-to-peer IPTV.

Seamless Wireless Access

In order to address the mobility requirements of Next Generation Mobile Networks (NGMNs), NLE enhances state-of-the-art mobility protocols in order to achieve seamless device, session and network mobility across multiple heterogeneous radio access technologies. This requires new, smart functions on terminals as well as in the network. NLE optimizes WLAN and WiMAX products by increasing the maximum number of high quality VoIP calls per hotspot and increasing the battery lifetime of mobile terminals. NLE develops methods for local and global self-optimization in the network in order to increase user satisfaction by providing the best connectivity within a given environment.

Security and Protection for Voice over IP

With telephony and TV services converging on the Internet as common platform, these traditional services will become exposed to new threats. Generating unsolicited 'spam' voice calls will become much easier and cheaper in Next Generation Networks than it was in public switched telephony networks. Also other kinds of attacks including denial of service and fraud need to be anticipated. As a pioneer NLE has developed a sophisticated Security Framework called VoIP SEAL™ for VoIP and other SIP-based services and will continue to lead technology development and standardization in this area.

Identity Management

NLE recognizes Identity Management as a key convergence technology of the future. Today, users face the problem of maintaining many different identities for different services. Innovative identity management by a trusted identity provider will bring these different identities together. NLE pioneered the "virtual identity" approach together with partners in Europe and has already developed several key identity management components. Our identity-driven architecture liberates the user from the devices. The user's online identity will be used to securely access everything from networks to services to content, using either one or multiple terminals. The approach NLE is following is cross-layer, and combines privacy, security, mobility and context management technology.

Exploring New Services

Ubiquitous and Converged Services

Networking technologies have infiltrated private and professional lives. It is easy to envision that the rapid expansion will encompass further areas of our lives: invisible sensor and actuator networks, ubiquitous local connectivity, the growth of a world-wide converged Next Generation Network (NGN) infrastructure, as well as new networking technologies like Car-2-Car, 4G, or broadband wireless.

Today, networking technologies are becoming the basic enabler for a growing market with rapidly changing conventions – the service driven economy. The essential know-how, expertise, and intelligence of today's knowledge-based society are reflected in highly specialized services. These services are made available to a global market. Services can be bought, combined, packaged and re-sold in order to create new services. As convergence progresses, the service world includes not only IT, Web, and telecommunication services, but also television services, social networking services, traffic services, home services and further areas of our social activities. Services are becoming the basic building blocks of the coming economies and of social interactions of people.

To meet these challenges, the Network Research Division focuses on three major areas introduced in the following sections.

NGN Service Delivery Platforms

In the area of NGN Service Delivery Platforms (SDP), NLE focuses on new technologies for delivering services. Within NGN this involves delivery of multimedia services, messaging, content management, information retrieval, eCommerce and many other types of services. A user-oriented architecture is under development in which services will be personalized to the user's device environment and delivered to end-users regardless of the network currently used. Services will be adapted to the multitude of available devices, and allow mash-ups between several different service eco-systems. The SDP platform has a strong focus on mash-ups technologies, allowing integration of service building blocks under the control of associated policies and with personalized service interaction management.

Internet Television

Internet Television (IPTV) is promising to enrich traditional broadcasting TV with new features such as interactivity, non-linear viewing, and value-added services. Research focuses on understanding how NGN networks and services and Internet technologies could be used to deliver value-added services to enhance the IPTV experience. The goal is convergence of existing media, home, telecommunication, and Web 2.0 services around the TV screen. In an increasingly networked world, the TV viewing experiences will also be shared and new media (like user generated content) will be jointly accessed. The underlying service platform needs to deal with different convergence aspects like media synchronization, metadata handling, cross-media recommendation systems, and various interaction mechanisms.

Context Aware Services

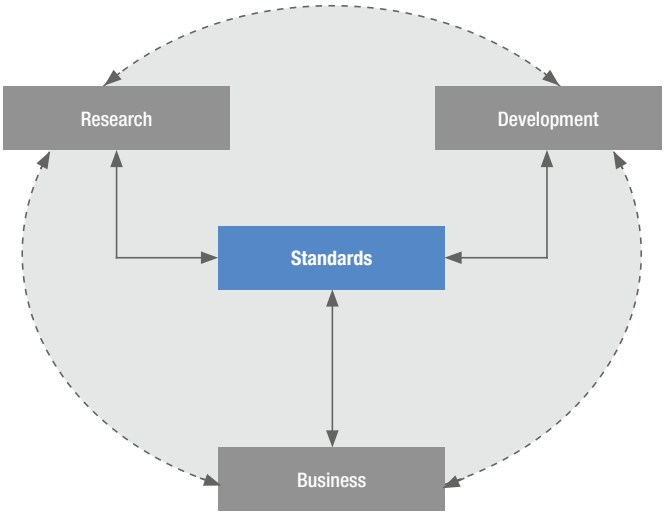
The Network Research Division is looking at new service enablers for converged networks. An important enabler is context utilization whereby the ubiquitous network infrastructure senses information about the user's environment, his social context, and the situation he is in. A context utilization service platform analyzes and utilizes this information to provide new attentive services. Semantic technologies based on ontologies as well as environment models (e.g. maps, 3D models, etc.) will be used in this process. This permits creation of customized services using service adaptation, pro-active interactions with the users, and ubiquitous support through utilizing resources from all communication spheres around the user – his personal area, the networked environment (e.g. home networks, smart buildings, or personal overlay networks), or from the virtual cyber world.

Standardization – Key to Global Markets

Standardization of data formats, messaging protocols, routing methods, interfaces, functionalities, architectures, requirements: an enormous effort is invested by governments, companies and people to create an interoperable, robust and efficient telecommunications infrastructure. Not only products, jobs and whole economies depend on a robust infrastructure: lives depend on it too.

NLE is helping to design a safe and efficient future global telecommunications infrastructure, for example by contributing to the handling of emergency calls in future All-IP or Voice-over-WiFi networks or by prioritizing car-to-car messages containing icy roads or collision warnings for highway traffic.

NLE closes the virtuous circle of research, prototyping, product development, market research and standardization: attractive ideas are feasibility-tested in prototypes and trials, considered in relation to market needs, promoted towards product groups of the worldwide NEC Corporation, and (in parallel) promoted as global standards. In this way, the total time-to-market is reduced and the interoperability of those products in the market is enhanced.



NLE contributions to European and international standards bodies or fora also aid the strategic positioning of NEC technologies, products and corporate image. NEC is a member of over 60 standards bodies and fora, whereby NLE plays key roles in about a dozen of these, briefly introduced in the following sections.

The **Internet Engineering Task Force (IETF)** defines the de-facto standards for the Internet. The goal of the IETF is to develop one common network layer standard. There are no corporate memberships, but there is a wide participation from industry and academia. NLE has a long history of participation starting in 1998 with a focus on Internet management, signaling and control.

Third Generation Partnership Project (3GPP) is the standards body which defines cellular networks of the GSM and WCDMA types most common in Europe. NLE has been a key promoter of All-IP networks for future purely packet-switched communications, and continuously brings contributions for refining the architectures.

ETSI is the European venue for telecommunications standards. NLE is actively contributing to *ETSI Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN)* defining fixed-line networks, particularly for the new NGN packet-switched networks with quality of service control, and *ETSI Intelligent Transport Systems (ITS)* comprising service groups/service domains designed to improve the safety, reliability, efficiency and quality of transport service provision and its enjoyment.

IEEE is working on global standards for IT and telecommunications. IEEE 802.11 (Wi-Fi), 802.16 (WiMAX) and 802.21 groups are all working on non-cellular radio protocols and NLE staff members are co-authors of several protocols. The barriers towards 3G cellular systems are disappearing: 802.16 (WiMAX) has been accepted by the ITU-T as one family of IMT-2000 telecommunication network standards, like GSM and WCDMA.

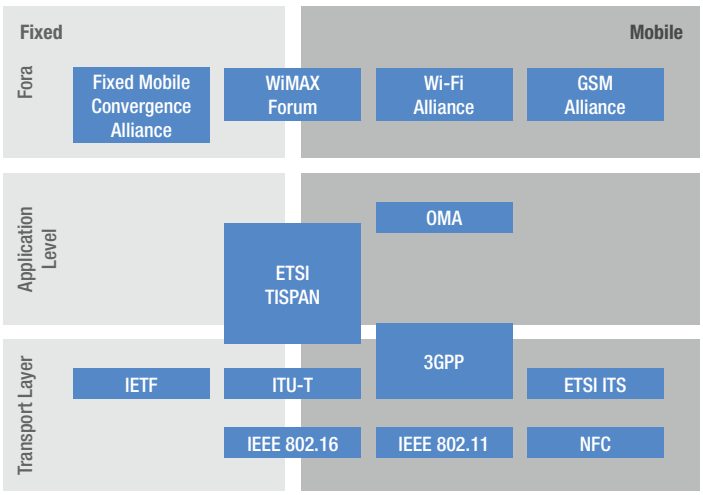
The **Wireless Fidelity (WiFi) Alliance** is an industry forum set up to ensure interoperability of IEEE 802.11 equipment and NLE has been a driving force in the Mobile Convergence group which considers certification issues for dual-mode devices. A NLE staff member chairs that group and is often invited to represent the Alliance at public events and trade conferences.

NLE has been involved in the **Wireless Interoperation for Microwave Access (WiMAX) Forum** from an early stage, helping the forum find consensus amongst hundreds of vendors for functionality of WiMAX equipment. NLE provides the chair of the compliance task group and a team which contributes to many of the Working Groups.

ITU-T is the international venue for agreement amongst governments on crucial issues such as radio spectrum assignment. Only high-level representatives are approved as delegates and NLE is privileged to provide a staff member as delegate. NLE is particularly promoting privacy and security issues through Identity Management, which is a major enabler for IP services and new business models.

The **Open Mobile Alliance (OMA)** develops and tests service enabler specifications, which build the basis for the creation and development of interoperable end-to-end service, mainly for the mobile but also other service domains. NLE has a team which has been extensively involved in this alliance since its creation in 2002 with a focus on Converged IP Messaging, Device Management and Mobile Broadcast.

The **Near Field Communications (NFC) Forum** is developing specifications to enable new markets in "contactless" payment and object tracking. NLE contributes to defining the modular architecture and parameters for NFC devices and protocols and is establishing a compliance program for testing and certifying products to ensure interoperability.



Standardization with focus on fixed-mobile convergence

IT Research Division – from Single Chips to Global IT Systems

A History of Collaborative R&D

Established in 1994 in the GMD Technopark in Sankt Augustin as the C&C Research Laboratories, NEC Europe (CCRLE), the IT Research Division was NEC's first European research laboratory. The first objective of CCRLE was collaborative research in the field of High-Performance Computing (HPC), mainly together with GMD Institute for Scientific Computing and Algorithms, which hosted a number of research-oriented NEC parallel systems (from the Cenju-Series).

Collaborative research and participation in the Framework Programs for Research and Technology Development of the European Union, with a focus in the Information and Communication Technologies (ICT) area, remains a key element of the IT Research Division's activities and has a tradition going back to the early years: In 1996, CCRLE collaborated with two projects within the ESPRIT IV research program, followed in 1997 by a leading role in the DRAMA project, addressing efficient use of parallel systems for dynamic numerical simulation.

High Performance Computing

HPC research has scalable, parallel programming methods and algorithms at its core. It provides a source of technology know-how for the IT Research Division's broader research themes in parallel and distributed computing.

The Parallel Programming Challenge

The developing IT landscape requires systems that can deliver solutions to increasingly complex problems with expectations for decreasing response times and power consumption. These seemingly contradictory requirements can be met by the use of parallelism at both chip and system level. Thus, parallel computing becomes a pervasive technology for IT systems. Since the breadth of deployment is much wider than the technical computing field, where mature parallel software exists to a large extent, the challenge lies in creating programming paradigms and interfaces that are able to: (1) deal with new levels of multi-user, multi-application concurrency in both mobile and single-server systems, (2) handle an increased breadth of computational algorithms, and (3) provide appropriate migration paths for existing serial software.

The IT Research Division takes up this new parallel programming challenge with R&D into parallel application building blocks and application programming interfaces for computing systems across the range of scales and with varying forms of interconnections and processor heterogeneity.

Distributed Service Computing – Beyond Parallel Computing

Defining the right mechanisms for collaboration and concurrency are not just topics for parallel computing, but arise in the developing ICT landscape for enterprises – realized by service architectures at intra- and inter-enterprise levels and in the delivery systems between service providers and customers. Distributed Service Computing has been the focus of the IT Research Division's research and contributions to a number of European projects on Grid Technologies and ICT for Health areas (e.g. GEMSS, NextGRID, SIMDAT and @neurIST).

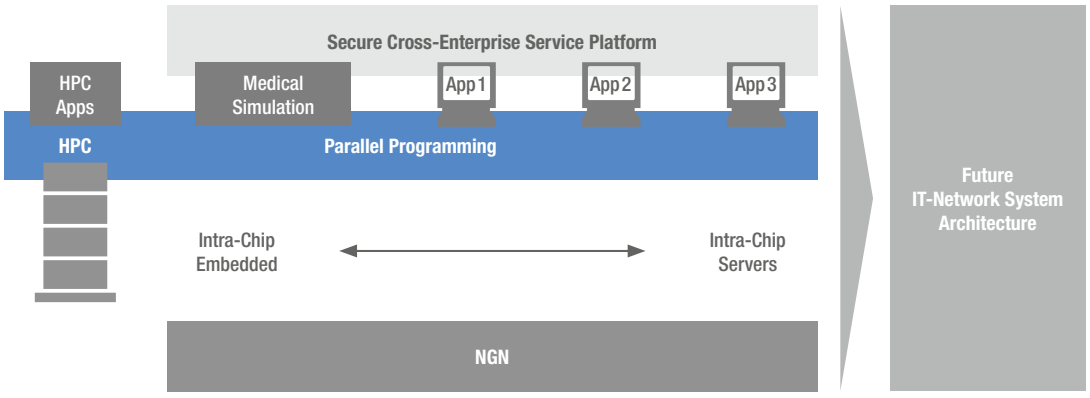
Distributed computing, with Grid computing as a specialized form of it, can be viewed as a generalization of parallel computing in that computational tasks are solved by contributions from a number of collaborating computer systems – but the computational task need not necessarily be a single-task computer program, rather may be represented by a workflow of sub-tasks with various interdependencies. In the distributed service environments for enterprises, key strategic issues that arise beyond the organization of computational tasks are e.g.: ensuring security and trust-worthiness of the interacting systems; incorporation into operational and business models and procedures.

Integrating Distributed Services with new Network Paradigms

New network service possibilities, next generation networks and ad-hoc and ambient networks, combined with both distributed service computing and distributed parallel computing systems, generates exciting new possibilities that are being investigated by research projects spanning the NLE research divisions. These projects include both enterprise service platforms and the development of new system architectures for ICT systems addressing environmental issues for energy efficiency and safety.

Another Convergence: Parallel Computing and Distributed Services for Future ICT Environments

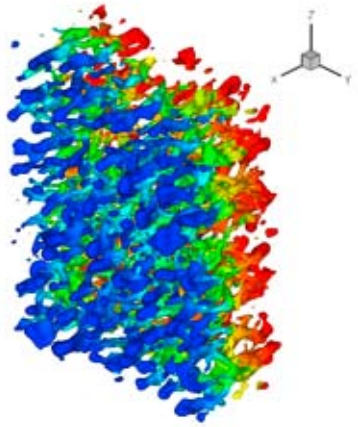
The current research activities of the IT Research Division bring together all the research areas discussed above in a way that can be illustrated in the following figure.



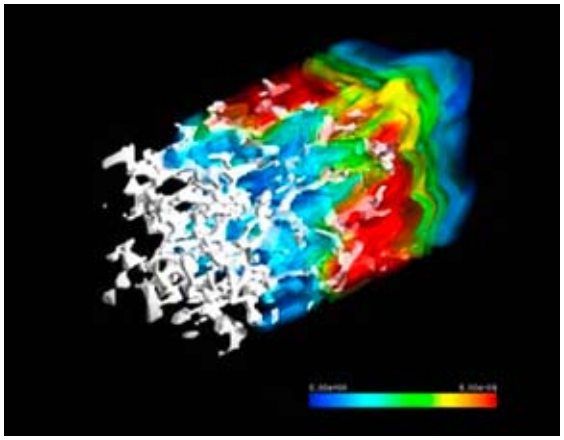
NLE-IT Research Map – Tecnology View

Parallel Applications and Interfaces

Exemplary distribution of a porous media domain to Parallel Multinode System



Lattice-Boltzmann simulation of flow through a complex Diesel particle filter geometrie



Lattice-Boltzmann flow simulation with a catalytic chemical reaction

Parallelism is Everywhere

Parallel processing was for decades more or less synonymous with High-Performance Computing (HPC). It provided computational performance for solving the most challenging and demanding scientific problems. The appearance over the last decade of affordable clusters and powerful interconnects has gradually pushed these techniques into the realm of standard engineering and business solutions. Today, parallel programming is entering into the area of everyday applications.

The IT Research Division of NLE develops parallelization libraries and parallel solutions for scientific and commercial problems, for instance in computational climate research, financial applications, Computational Fluid Dynamics (CFD), and entertainment (video streaming and gaming). NLE's highly efficient, parallel CFD software (based on the Lattice Boltzmann method) is used e.g. in medical physics (blood flow simulation) and automotive industry (Diesel particle filter). Collaborating with finance industry partners, NLE develops parallel and distributed software solutions for derivative pricing and portfolio optimization.

An important focus of NLE's work is to provide means and methods of parallelization through research and development of general purpose parallelization and communication libraries. Examples are Message Passing Interface (MPI) and domain specific parallel interfaces, like the PRISM coupler for Earth system climate modeling. MPI is the de facto standard for implementation of parallel applications for dedicated clusters and high-performance systems (like the Earth Simulator). An efficient MPI implementation must incorporate the best known algorithms to optimally exploit the given hardware. NLE develops such MPI libraries for the NEC SX parallel vector computers, the Earth Simulator, and for NEC's clustered, scalar systems.

Parallelism Precludes “Heat Death” of Future Electronic Devices

Today we are on the verge of a radical shift, which will make parallel processing pervade all areas of computing. The reasons for this are two-fold. First, the doubling in clock rates every 18 months (sometimes referred to as Moore’s law) is not likely to continue, so that the increasing performance needs in everyday applications (e.g. entertainment) cannot be met by traditional, sequential computing techniques. Second, the disproportionate increase in energy consumption associated with increased clock rates cannot be sustained – neither in the area of embedded and mobile computing, nor in traditional HPC. Parallel processing can however increase performance at constant or even decreasing energy costs (by lowering of the clock frequency).

The prerequisites are efficient tools to abstract the necessary parallelism from the computational problems to be solved. This shift in computational paradigm is witnessed by a proliferation of so-called multi-core processors for both general and special purpose computing, and with highly varying characteristics.

The advent of multi-cores will pose major challenges for research and development in both parallel applications per se and in general interfaces and support libraries for aiding in parallelization of new applications. NLE is at the forefront, developing a novel Task Parallelization Interface (TPI) based on division of work into independent tasks, using dynamic scheduling for efficient exploitation of available resources in highly dynamic mobile applications. TPI will thus serve as a basis for multi-core software development in the coming years.

Real Time Ray Tracing

using Task Parallelization

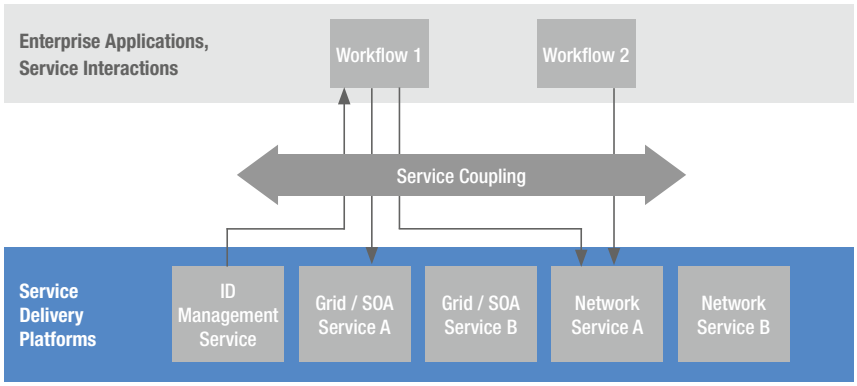
Next Generation Enterprise Service Infrastructure

Future Enterprise Needs

Enterprises in future Internet-based service-oriented economies need to be able to quickly adapt to rapidly changing business needs. This requires a high level of automation, mapping abstract business processes to low level ICT capabilities. NLE's IT Research Division is creating an agile, adaptive, service-oriented infrastructure for providing networked IT resources as part of integrated business solutions. While most of the existing infrastructures are currently operated within the confines of a single company, NLE's vision is a general internet-scale ICT backbone for the future service-oriented economy.

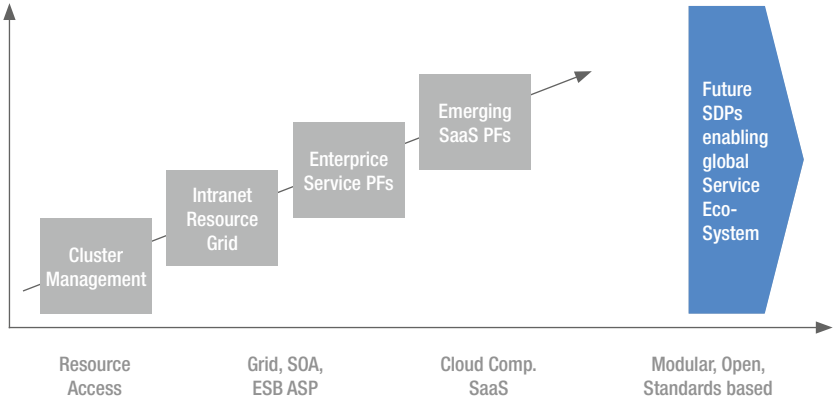
Towards a Global Service Marketplace

Software-as-a-Service (SaaS) has become a major driver for the IT business. Starting from cost efficient access to software, the emphasis has turned to integrated cross-enterprise solutions with the ability to dynamically create multi-tenant services for business processes and enterprise workflow. Related research at NLE focuses on technology to enable Service-Oriented Architecture (SOA)-based business processes, such as enterprise applications, to be created, managed and deployed on demand. Strategic research areas for realizing the vision of a global service economy include: next-generation SOA for cross-enterprise collaboration and eCommerce, future SOA runtime systems, Service Level Agreement (SLA) lifecycle management, service quality assurance, virtualization, and semantic technologies.



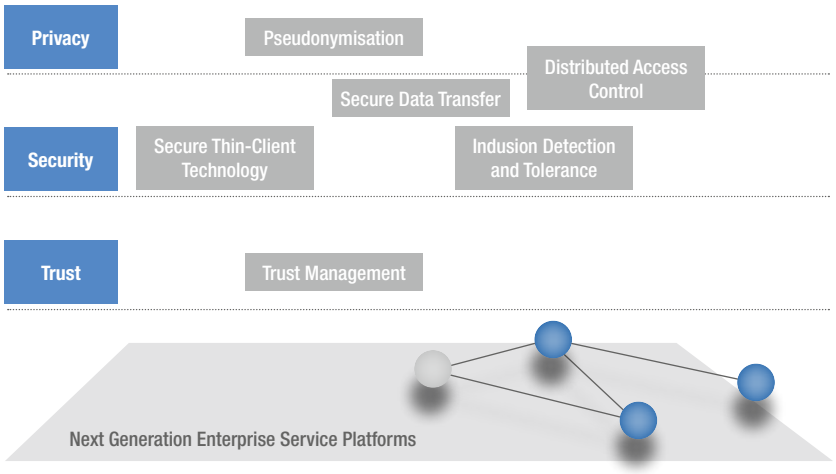
Next Generation Networks – Next Generation SOA/Grid Integration

Web2.0/Enterprise2.0 companies are challenging traditional business models in the telecoms world using innovative service models. The major telecommunication carriers have recognized the rapid growth of the SaaS market as an exciting new opportunity. There is a clear need for convergence of distributed IT and wide area networking technology. A major goal of NLE's research is the full integration of network connectivity with general IT services, bringing together Next Generation Network (NGN) and Next Generation SOA / Grid capabilities.



Standards for the Digital Networked Economy

Well defined and widely agreed standards are important to guarantee broad adoption and to limit economic risks. Successful innovation needs both collaborative research and consensus in standardization. NLE is active in the newly created ETSI Technical Committee, GRID, to produce interoperability standards in the context of IT and telecommunications convergence.



Integrated Security Solutions for Future Service Ecosystems

The commercial success of present and future distributed environments is highly determined by the quality of the integrated security, trust and privacy mechanisms. NLE has already developed innovative end-to-end solutions for message and web-service layer security, privacy protection, distributed intrusion detection and distributed access control. Concepts and implementations have been verified in large-scale collaborative projects and have been successfully transferred to NEC products.

As a core component, NLE's innovative distributed access control system allows the efficient setup of collaboration relationships including distributed policy management and enforcement capabilities. It supports the smooth integration of existing control components, adding complementary privacy and filtering mechanisms. NLE designs integrated and comprehensive security solutions beyond existing approaches, to exploit the full potential of the next generation service infrastructure, providing intrusion tolerant systems, user-centric privacy mechanisms, trust management and new approaches to secure, event-driven service infrastructure.

Marketing – Identifying Future Needs

As a corporate research laboratory, NLE treats marketing as a two-fold process: (1) acquire early information on technology trends and requirements, and (2) get early feedback on the application of new technologies and on ideas for new products.

From the first day of operations, NLE created a team for capturing user needs, analyzing markets trends and supporting the promotion of NEC advanced research in Europe and across the world. Current marketing activities are carried out mainly in London and Heidelberg. The outcome is essential to NLE for a variety of reasons.

Market trends and forecasts are used to assess NLE's current research projects against market requirements and evaluate the business impact of NLE's research. Market trends are also used to identify future research directions of NLE and therefore influence the mid- and long-term research planning.

Knowledge of European markets is often used to provide specific on-demand insights for NEC product divisions and research centers around the world.

Another main aim of the marketing activities is to support the promotion of NEC products across Europe. This is done through presentations at NEC sites, at telecom operators' premises, or at trade fairs or marketing conferences.

NLE marketing and promotion activities have been very successful, as proved by the growing demand for support received from various groups within NEC. NLE support important events such as Mobile World Congress or ITU-T Telecom World and a range of marketing conferences around the world. The strong demand of this type of activities is a clear indication of the value of a holistic marketing/technical/R&D approach to communication with customers.

NEC Corporation – a World Player

NEC Corporation, established in 1899, is a world-leading provider of components and systems primarily in the business domains of IT/Network Solutions, Mobile/ Personal Solutions and Electron Devices.

The IT/Network Solutions business provides components and integrated systems for ubiquitous networking mainly to government agencies, communications service providers and private-sector enterprises. This business offers world-class technologies in both IT and networking and has an extensive track record in constructing large-scale open, mission critical systems for both fixed and mobile communications.

The Mobile/Personal Solutions business provides mobile handsets, personal computers and other terminals that make services available to individuals. This business underpins the NEC brand with leading-edge technologies that realize enjoyable features and user friendliness, as well as finely tuned support services.

The Electron Devices business provides semiconductors, liquid crystal displays, electronic components and other components that play a central role in realizing high performance devices mainly for digital home electronics and automobiles. Its business' strengths lie in its ability to propose optimal solutions based on unique cutting-edge technologies that meet the requirements of worldwide customers.

In fiscal year 2007 (April 2006 – March 2007) NEC Corporation was represented in 44 countries worldwide by 342 subsidiaries with more than 155,000 employees and a total turnover of approx. USD 39.4 billion.

As innovation is the wellspring of NEC's competitiveness, NEC Corporation has constantly conducted R&D activities from medium and long term perspectives based on insight into the directions of future technologies and NEC's businesses. In fiscal year 2007 NEC Corporation spend approx. USD 2.8 billion on R&D, corresponding to approx. 7.2 % of turnover.

NEC Laboratories Europe

Over 100 professionals, from more than 16 different countries, are researching and developing the future in IT and networks at the three exciting locations of NEC Laboratories Europe: Heidelberg, London and Sankt Augustin.

Sankt Augustin – Science Site in the romantic Rhine Valley

The strong presence of large research establishments and world-class academia made the Cologne/Bonn area, in the western region of Germany, attractive to NEC when locating the IT Research Division in Sankt Augustin. This was NEC's first European Research Laboratory, founded in 1994. Today several UN organizations, large German enterprises (e.g. Deutsche Telekom, Deutsche Post) and many small/medium enterprises in the IT field reside in the prospering Cologne/Bonn area.

London – Europe's main Center for Business and Finance

London is well known as a major centre for European business and finance in addition to its cultural and historical prestige. The UK took the lead in the deregulation of telecommunications, spawning a vibrant industry attracting many international companies to London. NEC Europe and NEC UK headquarters have been based in London since 1971, in proximity to these major industry players and associated highly skilled professionals.

Heidelberg – City of Romanticism and Research

Research infrastructure and excellent connectivity to most parts of Europe were the main reasons for NEC to select Heidelberg as location for its Network Research Division back in 1997.

Heidelberg has historically been a center for philosophy and science with great minds like Georg Wilhelm Friedrich Hegel, Robert Wilhelm Bunsen, Max Weber and Carl Bosch. Heidelberg has the oldest university in Germany, founded as Ruperto Carola in 1686.

Community and Social Commitment

"NEC Make a Difference Drive" is a worldwide campaign that exemplifies NEC's contribution to good corporate citizenship. It was first introduced in 1999 when NEC celebrated its 100th anniversary and has been an annual event ever since, with ever growing participation of NEC employees – all over the world.

"Make a Difference" refers to making communities 'different' by improving the quality of life. It also refers to the 'difference' that participating employees and companies will experience through dedicating themselves to their communities. The purpose of this campaign is to foster NEC volunteerism, strengthen NEC group companies worldwide and increase visibility of NEC in local communities.

In the context of MDD, NEC translates to "Nature, Education, Community" which also defines the scope of MDD activities. Earth conservation, education, social welfare, arts, culture and sports are major focus areas of MDD activities.

NLE supports this initiative and has in the past received not only NEC-internal, but also local government and regional awards. Besides the good corporate citizenship aspect, MDD brings volunteering employees insight into different conditions of life, collaboration with colleagues in new contexts – and a lot of fun! These are maybe the key reasons for the great success MDD has within NLE – and within the communities addressed. The following examples give some impressions of this.

The IT Research Division in Sankt Augustin supported an IT-workshop for mentally handicapped adults. Another MDD activity, was with a local school for physically and mentally handicapped children. At the end of the workshop the children were invited to visit NLE. For both activities, the IT Research Division in Sankt Augustin received the NEC "Best Practice Award".

The Network Research Division in Heidelberg assisted a local kindergarten with the construction of a special path in the playground. Another year, the division assisted in a larger project with a local high school. Both initiatives were highly appreciated and, besides receiving NEC "Best Practice Awards", the second also won external communal prizes, as well as the regional "Aktie-e 2007 Award" for excellent corporate citizenship.

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