ICT Innovation Platform Intelligent Communication
Strategic Research Agenda

IIP Intelligent Communication Strategic Research Agenda

Preface

The ICT Innovation Platform Intelligent Communication (IIPIC) is proud to present its Strategic Research Agenda (SRA) for research in telecommunications. The IIPIC community of researchers, stakeholders and other people interested in this field has together built this inspiring and relevant research agenda for telecommunications in the Netherlands. This new SRA will help us to develop research programs, to steer individual research efforts and to attract new resources.

About ICT Innovation platform Intelligent Communication

The IIP Intelligent Communication brings together researchers, companies and institutes that engage in intelligent communication solutions, supporting end-users, groups and organizations in the specific context and needs of their daily life, activities and work processes.

The IIPIC community resulted from the project-consortia in the BSIK Freeband program, which has successfully delivered its last results end 2008. IIPIC was formally started in 2009 (supported by ICT-Regie) and became an independent foundation in March 2011.

Summary

Personal communication facilitates the exchange of information and emotions between (groups of) individuals. In most relevant applications, personal communication is facilitated and mediated by technology, e.g. computers, portable devices, sensors, internet, and (mobile) network infrastructures. Communication technology is, and will remain to be, a critical factor in many economic and societal sectors: for instance for health and well-being, entertainment and creative industries, mobility and logistics, and digital cities.

With the term "intelligent" we mean that communication systems will incorporate awareness of their heterogeneity and distributed nature, of their expected dependent and secure operation, and of their close collaboration with human users. No fully functional intelligent communication infrastructure exists to date. However, an operational intelligent communication infrastructure is tacitly assumed to be "ready for use" for most applications.

The ICT Innovation Platform (IIP) Intelligent Communication seeks to bridge this gap. In this document IIPIC has explored three important societal domains to search for technological challenges and opportunities: health and well-being, smart mobility systems and smart energy systems. Below we summarize the most important outcomes for the IIPIC community. In the text we also refer to the related EIT ICT Labs themes. Members of the IIPIC community can apply for ICT Labs funds for education, business-development or innovation funds.

The **Health and Well-being** domain has been explored many times, but on the basis of this SRA research we identified three opportunities for IIPIC, that are aligned with the new top sector of life sciences and the EIT ICT theme of Health and Well-being:

- The design and deployment of a health application platform for health related services, including an AppStore (and platform) for health services. Such services may support for instance telecare, with proper security and authorized access to relevant data.

- Contributions to safe and reliable communication across local (home and regional) communication systems, in order to ensure reliable connectivity but also with the possibility of prioritized communication across administrative domains in case of emergency situations.

- Improvement of the up scaling and uptake of new technology solutions within the health domain.

The **Mobility** domain has recently received much interest. Important observation is that while there are efforts to unite this sector (Connekt, Dinalog, IIP MAIS), there seems to be no concerted effort from telecom parties to address the challenges that originate from the proposed ITS solutions in this domain. The mobility domain is related to the top sector Logistics, and the EIT ICT Labs themes of ITS, Smart Spaces and Digital Cities. The mobility domain gives rise to the following IIPIC topics:

- Use of smart cognitive devices: their cognitive aspects allow them to easily join and leave a network. For instance within a car, between cars, between cars and roads, etcetera. Devices vary in capabilities (and power requirements). Low-power versions often use energy harvesting techniques. Others can be tablet-like or smartphones and require batteries.

- Recognition of mobility patterns using smart sensors (e.g. on smartphones). This can be used to provide insight in personal mobility patterns. This, in turn, will enable personal driving directions and even incentives for changing usual patterns in case of unforeseen road incidents, certainly when they are shared in 'private' social networks.

- Fusion of open data: what is the business model so stakeholders buy-in? What type of standards is required? We should also consider 'nice-to-have' services for end-users next to, for instance, professional traffic control services.

- Improving the scalability, safety and privacy of proposed Intelligent Traffic Systems solutions.

Smart Energy Systems: The added value of new communication technologies in the energy sector is very high. Electricity can only be stored at high costs - to the extent that today specific users are paid in hours of excess supply to consume electricity - and thus managing demand and supply is highly economical. This situation exacerbates when energy-supply increasingly decentralizes and the use of electrical cars would increase. The smart grid is the proposed solution to these problems. This is also one of the cornerstones for the top sector Energy and the EIT ICT Labs theme of Smart Energy Systems. Part of the communication requirements for a future smart grid can be met with existing and future generally available communication infrastructures. However, several questions need attention:

- What will be the architecture of the communication infrastructure and management platform that supports the smart grids vision and how does it include various currently available infrastructures? How can the different reliability levels of

different sets of data be managed, and how does the system deal with disturbances? The communication infrastructure and platform should also anticipate the application development by third parties.

- How should data from different sources be integrated? Questions refer to reliability of data transport and standards for data communication between energy providers, equipment providers and users, and between users. This also includes privacy issues and potential business model challenges when data needs to be shared among consumers, prosumers and grid-operators.

- How can the transition be organized between the current distribution networks and a future bi-directional smart grid from both a technological and business model perspective?

Cross-cutting challenges

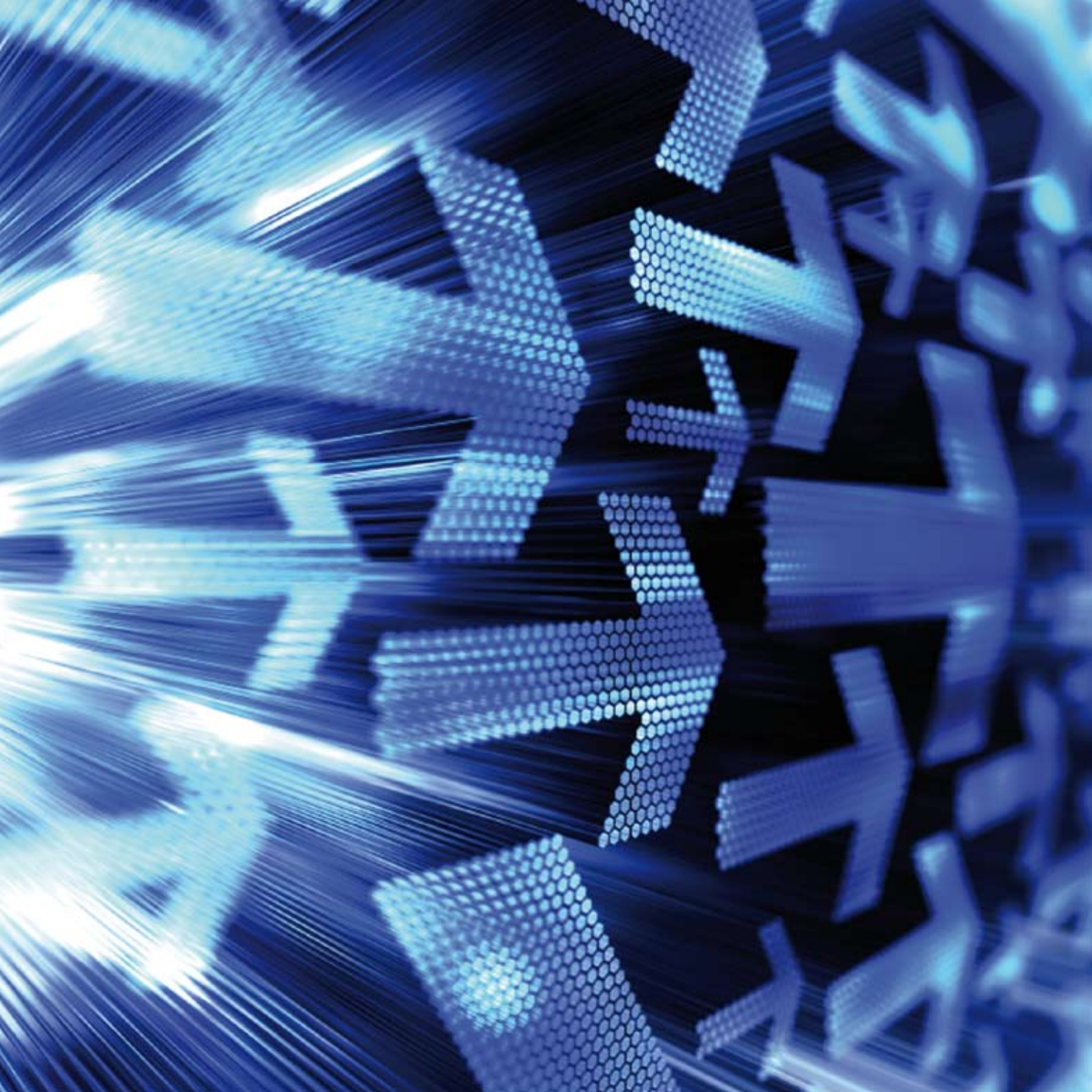
From the challenges above we can derive research topics for the IIPIC community. Key questions are:

- How to deal with reliability and prioritized communication over heterogeneous networks

- What are requirements and technologies for open application platforms in order to effectively support third party applications and services (e.g. basic platform services and software-development-kits)

- How to access, exchange, provide and control data coming from various sources, complying with standards while ensuring privacy and scalability

- Significantly increase the availability of solutions in domains with strong availability requirements. Implementation and upscaling of new networking and service technologies in domains may require new concepts.



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Introduction

Intelligent Communication

Communication is the art of exchanging information. It is an essential ingredient of life, inside and between organisms, and it also takes place between devices that contain 'artificial intelligence' such as computers and intelligent sensors. It is achieved by a combination of 'access to' and 'transmission of' information across communication channels and networks. This started with the plain old telephony system (POTS) that provided global audio connectivity throughout the 20th Century. This network lacked portability and mobility. These drawbacks were addressed and resolved by subsequent generation's communication technologies. The main exponent of the second generation (2G) wireless systems was GSM - it supported portable and mobile voice transport services, while UMTS (3G) added proper data communication to it.

While speed of wireless links increases with a constant rate (Edholm's law), at the same time the volume of intelligent devices decreases with a staggering rate as well. The intelligent devices of the 70ties and 80ties, mainframes, minicomputers and PCs, were connected with the emergence of Internet. Remarkably, the way computers communicate using Internet solves the second problem of digital communication: ubiquitous access. A computer is permanently on line and has access to the whole world via the internet. 3G, and its successor 4G, combine the best of both worlds and allow connectivity at any place, at any time and for any type of medium. 4G intelligent communication solutions support end-users, groups, organizations in the specific context of their daily life and operations by immersing them in an information society. Connectivity, or the possibility to communicate, has become the key enabling factor for all forms of economical, societal, political, or educational relationships and activities.

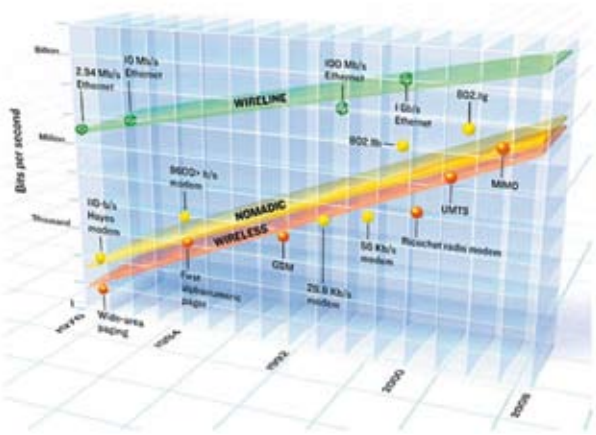

Figure 1: *Edholm's law illustrates how the telecommunication technologies march almost in lock step: their data rates increase on similar exponential curves, the slower rates trailing the faster ones by a predictable time lag.*

New communication technologies are rapidly changing society. Individuals are increasingly immersed in a world with all sorts of devices that can interact with them; e.g. smart phones, displays and home stations. These devices should understand the user's information needs and act accordingly. The result is an ambient intelligent communication environment brought about by a combination of sensors, applications, devices, software services and communication technologies. People and applications will communicate with each other through the appropriate networks - fixed or mobile - which are seamlessly intertwined.

Figure 2: *A graph showing how traffic is expected to grow throughout the coming years, and distributed geographically. 'CAGR' is 'Compound Annual Growth Rate'.*

The impact of intelligent communication is that users will have a stronger sense of control over their own life, and this will be irrespective of whether they are at work, undergoing medical treatment, traveling or interacting with agencies, or in a social context with family or friends. A patient, for example, will become less dependent and will enjoy a better quality of life in his own, trusted environment. A police-officer will feel more secure in unfamiliar situations, being in contact with and monitored by his colleagues in the vicinity and back-office. Focused social interaction between (groups of) people will reduce loneliness and improve inclusion, social cohesion and well-being.

To realize this goal of being 'connected anytime, anywhere, anyhow' many issues need to be resolved. For a continuous Internet connection we probably need to rely on multiple access networks, such as WLAN, UMTS, GPRS, Bluetooth, etc., irrespective of whether we are a priori known to these networks or not. If multiple networks are available, the device that mediates our communication should use the one that is closest to our preference, e.g. the one with the highest bandwidth or with the lowest costs. But if we change network environment during travel, we do not want to change network settings or restart applications. The network should therefore know who we are, what services we want to use, what our preferences are, and who should eventually receive the bill. But this information will be continuously changing. In these dynamic settings, network and service providers should make a joint effort to guarantee a sufficient level of quality, security and privacy.

Communication technology and the Netherlands

In the past, the Netherlands has played a significant role in the development of technologies for wired and wireless communication networks. For wireless, with inventions like the GSM speech coder (Kroon-Sluiter), Bluetooth (Haartsen) and Wi-Fi (Hayes). And in optical networking with inventions like WDM - wave division multiplexing (Smit). The Netherlands also has a globally operating high-tech industry with an important role in high-frequency electronics with companies like Philips, NXP and ASML.

The Netherlands is a forerunner in high-end backbone, wireline broadband (DSL, cable, fiber) and in wireless 3G coverage (UMTS, HSPA). As such the Netherlands is one of the leading countries in the world in the field of connectivity and can be regarded as a Gateway to Europe. Furthermore, public acceptance of internet is very high and people are open minded, efficiency driven and early adopters of new technology.

The Dutch services economy accounts for 70% of the total Gross Domestic Product (GDP). Almost the entire growth in employment during the last decade stems from developments in the service economy. Sectors such as media, finance, business services, health and service/product combinations are pillars of our service economy. Being a service economy means that the

development focus for communication infrastructures will be influenced by the support of the communication infrastructure for specific application domains, e.g. in healthcare, media, public services, finance and education.

In 2001, a consortium of industry and academia decided that the Netherlands would benefit from a shared R&D vision to support the transition to a more flexible communication infrastructure that supports the needs of the Dutch economy and society. This resulted in the 'Freeband' vision. This vision on telecommunications described how in 2010 consumers and companies will have unrestricted access to information and communication, through unlimited bandwidth and highly sophisticated, personalized ICT services. As a result, the Freeband program started with the goal of raising the level of knowledge on telecommunications at academia in the Netherlands to an international top-level.

Current status in the world

4G is a logical evolution from 3G (UMTS) and fixed broadband networks towards an integrated system. While 4G is currently not realized as a whole, many technological and business developments suggest that 4G, and in particular Long Term Evolution (LTE), is well underway to become the new reality:

- Broadband xDSL or Cable connections up to 100 Mb/s transmission rates are deployed at a staggering rate in developed countries. In the Netherlands, we have a high penetration of broad band connection in the Dutch end-user market. Substantial FttH deployments will significantly increasing the average data rates over the coming years.
- Wireless Wi-Fi routers deployed in households are common. These offer data rates often above 54Mbit/s, with 802.11i security providing perspectives for increased protection. Wi-Fi data rates are boosted to 500 Mb/s (802.11n) and even 1 Gb/s (WiGiG).
- A new generation of integrated devices with extended viewing facilities and ubiquitous internet access are hitting the market. Such devices allow people to be connected anywhere, any time and with the best possible means. Typical examples are the smart phones and tablets that open-up the post-PC world and will change the way we experience successful desktop-pc services, such as internet telephony, RSS, infotainment, or social software. The winners in these new markets will be those who can integrate functionality in the most appealing and intelligent way.
- Unlicensed Mobile Access (now known as Generic Access Network, GAN) support seamless roaming and handover between local area (Wi-Fi) networks and wide area networks such as UMTS using the same mobile phone. First devices have appeared on the market that supports these features.
- Telecom operators offer subscriptions that allow users to use their mobile phone in home as a normal phone, based on

so-called Pico-cells (Wi-Fi routers that contain an additional 3G radio, connected via the home access connection to the selected 3G or 4G mobile network). This is completely in line with 4G fixed-mobile convergence: an all-IP, user-centric philosophy.

- Triple play telecom services that combine TV (media), voice, and internet browsing are becoming common. Quadruple play (including mobile services) is starting off.
- Blogs and content-sharing websites: global sharing of personal content like photos and videos has become possible with sharing websites of YouTube, Facebook and Flickr.
- The Internet is the communication and networking medium of choice. However, the Internet itself was not designed for this. New bandwidth efficient and liberal technologies for sharing information have emerged. P2P communication has invaded the internet as the main use case. This accounts for over 70% of traffic nowadays (June 2011), largely surpassing emails, web browsing and other applications. While at first mainly used for illegal sharing of content, these technologies are now being applied for mass-scale internet-based communication services. These technologies offer the promise of efficient use of network resources, essential e.g. for next generation television broadcasting. Examples are Skype, Joost, BBC-iPlayer and Tribler [1].

A new SRA for IIPIC

IIPIC has developed this strategic research agenda for research and development in Telecommunications.

What is an SRA?

An SRA is a Strategic Research Agenda: a Strategic Research Agenda identifies a set of research questions or research themes that are coupled to the ambitions, scope and roadmap of a certain domain or thematic area. An SRA serves as a joint starting point for actions plans, programs and projects. In this way coordination of activities is stimulated.

A demand driven approach

IIPIC represents enabling technologies in the field of communication technologies. The benefits of improving communication systems will be primarily harvested in application domains.

These domains were chosen because of their relevance for society and because the domain visions strongly rely on technological solutions to overcome current domain challenges. The underlying idea (assumption, belief) behind the IIPIC SRA is that society will benefit if there is a speed-up in the adoption of high tech solutions in these domains.

Application domains

What are the domains smart health systems, sustainable mobility systems and smart energy systems?

- *Smart health systems:* Healthcare is one of the most pronounced societal areas facing large challenges, involving patients, citizens, government, healthcare institutions and companies. ICT is considered an important enabling technology in many solutions. The solutions are typically targeted at early leave from hospital and longer stay

- *Sustainable mobility systems:* Mobility of persons and goods is a key asset in modern society; in order to preserve and enhance mobility new mobility solutions are needed that guarantee sustainable 'throughput', in an environment-friendly manner.

- *Smart energy systems:* With electric cars, smart grids and local, domestic energy production, energy delivery and usage is turning into a high tech system which will rely on information and networking technology.

Health and Well-being

Healthcare is one of the most pronounced societal areas facing large challenges, involving patients, citizens, government, healthcare institutions and companies. ICT is considered an important enabling technology. Health and wellbeing is a broad domain. It is often broken down into:

- **Cure.** This is the domain of hospitals: diagnosis, surgery and care are the main processes. From the IIPIC point of view there are challenges in the management of patient records, person-to-person communication, and wireless communication in surgery rooms. Treatment in hospitals is, in the Netherlands, funded by health-insurance companies on the basis of a well-defined treatment (status 2011).

- **Care centers** ('verzorgingstehuizen'). This is the domain of elderly and people that require a high level of care. These are financed by the government by means of the AWBZ (status: 2011). In 2012 the AWBZ funding will be rerouted through the health-insurance companies. The core business of care centers is to organize (personalized) 24x7 care services for their clients. There is a move towards decentralized care: smaller care-centers in neighborhoods, often requiring remote observation of inhabitants during out-of-office hours.

- **Telecare service providers.** These organizations provide services like vital-sign monitoring of individuals, connected either synchronously or asynchronously with a telecare center or hospital. Other variants involve smart homes; the in-home technology is connected to a telecare center and/or a general purpose alarm-centre. The business models for telecare are not really established yet. Telecare service providers are not always associated with a care-center; they can also be an intermediary between multiple care providers. Services are often tied together with specific hardware solutions, resulting in minimal interoperability between in-home solutions.

- **The care-chain.** Professional health and care centers have to cooperate: patient-centered care requires the combination of workflows across organizations, in combination with the exchange of the relevant medical data records. Concerns are process optimization, information security and privacy, efficient exchange of high-resolution images, and cost efficient operation.

- **Lifestyle, Prevention, and Well-being.** Prevention is both primary and secondary prevention. Ultimately, this is the domain that is driven (and paid for) by the consumer. Example services are support for fitness, cycling, or running. Assistance for cooking. Stop Smoking. Lifestyle coaching. Etcetera. Although some of these services are (co-)funded by employers, often they are paid for by consumers (e.g. via downloaded apps on smartphones in combination with a service-subscription).

Introduction

Health and Well-being visions are widespread. We quote a few of them:

IIP Health Support: "Care migrates from an isolated system (19th century), through (linear) healthcare chains (20th century), to networked care (21st century). There is continuous shift from cure to care".

European Foresight Network: "We depict the care that will be provided in a networked system and on an individual basis as personalized networked healthcare. The vision of **personalized networked healthcare** is to improve the quality of life and quality of care, provide individually tailored care at any location and support human persons in self management, and health professionals and voluntary care givers in better organized networked teams. Furthermore, personalized networked healthcare focuses both on healthy and disabled persons, supporting active ways of life, where cure and care are mixed with leisure and pleasure. Thus personalized care meets needs that arise from developments as sketched above in both society and care provisioning."

Domain challenges

In the table below we give the prominent domain challenges.

Domain challenge	Description
Waiting lists	Societal most pronounced and commonly known challenge: the need to wait before treatment can occur in hospitals, health centers or at medical professionals. This leads to the emergence of private hospitals for specific treatments.
Lack of personnel	Especially in care: nursing professions and informal care. We have an ageing society, which leads to a higher demand for care in combination with a reduction of the work-force.
Lack of resources (e.g. expensive MRI scanners)	Cost of procurement, duplication of equipment, non-optimal scheduling, waiting lists

Dealing with increased availability of new (costly) treatments	Due to scientific developments, the number of possible treatments increases. Potentially a multi tude of patient-centric and disease-specific applications, services and solutions is needed.
Fragmentation of care organization	Market is difficult to penetrate for newcomers, also due to regulatory issues; high entry costs Economies of scale difficult to achieve due to fragmentation. No clear problem owner; inhibiting the uptake of innovations. Hard to keep track of overall 'patient' process.
Financing structure	No clear problem owner; inhibiting the uptake of innovations.

In addition, the special character of the health and wellbeing domain puts special constraints on innovations and technical solutions. Boundary conditions to solutions are:

Ease of use. Care puts heavy demands on ease-of-use, because of

- users of technology vary a lot in skills, and
- technology is being deployed in critical circumstances, e.g. in operation rooms or in emergency situations, and should therefore be very intuitive

Robustness. System failure is not acceptable because it might lead to loss of life or loss of quality of life.

IIPIC Challenge for the Health and Well-being domain

The Health and Well-being challenge is meant to ***stimulate*** the explicitation of research challenges for the Health and Wellbeing domain, but also to provide ***focus*** and ***scope***.

Developing a national ICT platform for telemedicine: A platform that supports both mobile coaching, telemonitoring and teletreatment, and that is compatible with hospital systems on the one hand, and private (home) and semi-private (domestic cooperation's or nursing homes) on the other; and it should also allow for third party services.

In the SRA workshop it was identified that the platform should support use cases that pertain to

- Integration with the personal home environment (e.g. home entertainment and domotics)

- Integration with the regular cure processes and systems (i.e. hospital systems); with related Quality of Service equirements.
- Integration with social media application & community services.

Possible constituting building blocks:

- Platform framework of standards and interface definitions
- Platform services
- Service/Application Development Kit
- Platform adoption strategies and roadmaps

Scenario Health and Well-being 2025

Around 2025, care is organized different from today. Because of the continuously increasing number of treatment methods (with expensive technology), the costs of healthcare have surpassed all boundaries of the collective affordability. Health and treatment has in fact become a scarce commodity, so that economic laws put a much stronger marker on the organization of care than in the past.

Specialized centers, public and private, play a major role in the daily care as well as health counseling. This is both a direct consequence of efficiency targets and market forces. On the other hand it also has a societal cause: people with health and wellbeing wishes and demands (formerly denoted as "patients") want optimal care, and are no longer satisfied with an average 'treatment; this trend is further supported by increased mobility of people. Therefore many people are turning to specialist health centers. These centers (large and small) are often the result of cooperation between traditional providers and private organizations: insurance companies, employers and care providers (e.g. fitness centers, gyms and housing associations) that other than strictly healthcare-related reasons, invest in health and wellness.

The strict line between sick and healthy has disappeared. It has been replaced by a continuum of life-long well-being, in which an individual and his next of kin are basically responsible for seeking and addressing the right care at the right time. The market offers numerous telemedicine or self care solutions that meet the wishes and necessities of people to monitor their own health, in the most pleasant way possible.

Use case scenario: Somewhere in the not so far away future...

Marijke loves to exercise. In her 47th year she still feels pretty fit, and spends considerable time at her work as a casting

consultant. Still, life has left some traces. As a result of thrombosis with pulmonary embolism a few years ago, her lung capacity is reduced, and she is forced to swallow anticoagulants. But especially for her an active lifestyle is recommended if she wants to stay as healthy as possible. But her condition has made Marijke a tad uncertain. She keeps a close look on her heart rate and blood pressure during exercise, even though that does not directly relate to her lung problem.

Her gym reacts to her situation through its own portal by offering several health services that visualize various health aspects. The data from the Nike App on her iWatch are directly visible on the portal (which is why she wears the watch all day, precisely because of this functionality), but also the details of her last workouts including the response of her body to the training efforts. She has set the alarm somewhat sensitively, so that there is timely warning if her heartbeat shows deviations. Given her past health issues, she has also arranged for a warning signal to telecare-center in case of a heartbeat disorder. Because she knows that the web-portal has been developed in conjunction with a medically-recognized consulting firm, she knows that the portal is more than just a few inaccurate graphs. What's particularly nice is that once a month, the doctor at the sports center performs an extra scan of her data, to see if there are any peculiarities to be noted. For which there is no extra charge by the way.

She grabs her racket and a squash ball which is still cold. Then the phone rings. She sees immediately that the ringer is one the informal caretakers of her single mother, but from the green color of the screen she already knows that there is no alarming situation ...

Research questions for the Health and Well-being domain

Requirements

- The home network should be extensible. This home network should be future proof in order to support new applications, including robotics, or health support at home.
- The platform should support personalized user interfaces. How to design personalized user interfaces for people/patients?
- A platform should interface to social network sites, Instant Messaging, and e-mail
- A unified integrated health log should be available to patients. This should support the addition of new types of information, coming from multiple sources, in various formats and through a variety of channels.
- Resilience against failures. If the network fails critical messages (alarms, medication reminders ...) should still be given. Fall-back scenarios (e.g. via public mobile networks) must be available.

Technical Challenges

- Standardized data formats and efficient lower layer transport protocols.
- Ensure that sufficient bandwidth is available
- Define standard programming interfaces for services, that can dynamically switch between lower layers, and that automatically discover the most optimal network.

Data Storage

- How to deal with scalability of 24/7 monitoring with respect to data storage - should all (raw or processed?) data be stored - if so, for how long? Discard raw data and keep only processed data or high level interpretations/abstractions derived from that data? Thus losing the audit trail...
- How to select appropriate data or decide which data to be discarded or not; whichever choices are made, legal and privacy implications, as well as potential medical consequences, can follow.
- How to identify and use patterns in large amounts of sensor data?

Solution directions

- Define a virtual care network as an overlay over existing infrastructure.
- Create a Care Exchange: an application layer switch between (smart) homes and care centers.
- Unobtrusive monitoring using various technologies: For use in the extramural case this is a must to get it broadly accepted. This means reliable (i.e. handling artifacts), small (i.e. integrated), easy to use (i.e. battery-less, hidden in textiles) and low cost (i.e. ready for the mass market).
- Can we use Service-oriented computing as a solution?

Business models and innovation

- How to orchestrate care around a particular patient? Can this be related to the care-exchange from the previous paragraph?
- What are usable go-to-market strategies for in-home care solution providers?
- How to design new healthcare processes that reflect the available and upcoming technological possibilities?

Authorization, authentication and privacy

- How to arrange multi stakeholder access to information?
- How to guarantee the privacy of heath related data?

- Storage and retrieval services for medical (sensor) data. What are appropriate search algorithms? Data filtering and diagnostic recommendation

Proposed Actions and Opportunities

Proposed actions

- Develop a national program to take up the home-care platform challenge, and to actually build it.

Opportunities for getting connected to various HWB communities:

- Universaal Project on Open Source domotics:
- Health and Well-being program in EIT ICT Labs
- Topsector Lifesciences and Health ;
- Topsector High-Tech

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Smart Energy

Introduction

Sustainable energy production and consumption are critical components in dealing with climate change, CO2 emissions and exhaustion of natural resources. The load on the energy network is increasingly unpredictable. That's why in particular the power network needs to be upgraded to a smart grid: our energy system turns into a smart energy system. Smart energy systems support controlled charging of electric cars, deploys smart grids with local, domestic energy production, energy delivery and usage. This converts the electricity network into a high tech system which relies heavily on information and networking technology.

Domain challenges

These challenges are based on interviews and a careful analysis of existing roadmaps.

Domain challenge	Description
"Supplying the market with sufficient energy without building energy plants"	Home automation to reduce energy-waste.
	Create Smart Grids to more accurately predict periods with high or low demands.
	Influencing user behavior: much of the demand is still user-induced
Creating an infrastructure for electric cars	With sufficient charging stations capable of supplying the required energy
Delivering clean or pure power	Maintaining the "quality" of energy production and distribution.
Storage of energy	It is often cheaper to produce energy than to store energy.
Delivering richer services to clients	Energy is a commodity, utilities may exploit the 'smart meter' to deliver added value services

Extrapolation: These challenges are likely to become more prominent in relation to the increasing energy demands and requirements for sustainability.

Boundary conditions to solutions:

- Use of "proven technology". Extensive roll out of new technologies in experimental settings is needed before a national smart grid is realized.
- Long time horizon: energy grids have an economic Return of Investment (RoI) of tens of years.

Trends and Solution direction: Smart Grids

Smart Grids represent the cutting edge of energy efficient technologies, applied in energy production, distribution and householder use. Smart grids are modernized electricity grids that interact with information technology and communications infrastructure to provide greater transparency on energy use to consumers, and to improve the efficiency of energy supply. Smart grids support the integration of renewable and distributed energy sources into the grid, like solar, wind and co-generation plants. Smart grids promise to be more reliable, with fewer and shorter blackouts. They allow electric vehicles to be charged when demand on the network is low, and their combined battery storage can be used to support the network when demand is high. Consumers need no longer be passive receivers of power, but instead can take responsibility of their energy use and make meaningful decisions that will benefit both the environment and their hip pockets. From the perspective of commercial energy producers the most important aspect is peak-shaving: shifting energy consumption to periods with less energy demand. This can be done by providing incentives to consumers, or by remotely controlling household appliances. Many of these changes will help lower peak electricity demand and reduce the need for electricity companies to build extra power plants simply to cope with daily peaks in consumer demand."

Key elements of this vision are:

- Production of green ('renewable') energy. This can be done by commercial energy producers, but also by individual companies or households (solar cells, wind-mills).
- Support for electric cars & chargers. This leads to new local power demands on one side, and significant electricity storage on the other side.
- Smart Metering Infrastructure (SMI) and in-house controls, to provide insight in energy usage for inhabitants.
- Advanced tariff differentiation, to provide incentives to increase or reduce current power consumption.
- Information exchange in the energy supply chain, in order to predict energy usage and control energy production.
- Communities may support local trading of energy

- Local E&G/W&C projects: specific solutions not related to the main power grid (especially local Warmth & Cooling solutions)

Scenario Smart Energy 2020

The energy market is highly diversified. Many sources of electricity are used in combination (traditional sources like gas and coal, wind, water power, decentralized solar power, decentralized small energy plants). The supply mix and demand mix is fully automated, based on rules defined by users and energy suppliers. In other words, based on weather predictions, demand predictions and user rules decentralized systems decide whether it will load electric cars, adapt lighting on high roads, or adapt energy production in gas power plants. Energy companies are competing on price and intelligent customer services, like fully automated control of household equipment based on energy supply and prices and user preferences. The supporting ICT infrastructure in the home consists of fine-grained communication networks, which exchange (aggregated and/or anonymous) information with the energy company and various third party service providers via the Internet. Users become more aware of the variety of possibilities for utility services including home-specific solutions for electricity production and saving, heating and cooling, cooking and water management. Energy-consumption can be remotely managed and controlled through web-interfaces, on the desktop, touchpad or mobile. Support for energy equipment is managed by the energy company, using a supply base of local professional heating service companies.

Use case scenario: Somewhere in the not so far away future...

I get up early this morning: today we have to decorate the living room since it's my daughter's birthday! It's mid-winter and cold outside, but luckily the heating remembers this special day from last year. It's already warm in my bedroom and in the living room, while the other bedrooms will still be cold. Nice system. My only concern is all the personal data that my energy company seems to collect. They give nice privacy guarantees, but lately it was in the news that an energy company, not mine, had kept the data after the client had moved to a competitor, sending birthday cards to his wife reminding her of the nice time they had when still a client. And I still do not get why apparently it is beneficial that my microwave is web-enabled. Anyway, my invoice was lower again, particularly since cloth washing is done on last-minute low-cost hours. Just filling the machine in the evening and the wash is clean in the morning. Oh god, I still have to get it from the machine.....

Smart Energy Challenge

The Smart Energy challenge is meant to stimulate to make research challenges explicit for the Smart Energy domain, but also to provide focus and scope.

1. Development of a smart grid communication-infrastructure, connecting house holds, grid providers and electricity providers.
2. Provide a plug-and-play smart meter that can be obtained in a DIY-store.
3. Develop in-home (or in-company) communication and controls for local energy management

Research questions

Smart grids:

- Should the electricity grid manager(s) play a role in the home-to-grid(s)-to-producer smart grid communication?
- How can a smart grid deal with all parties involved in its operation?
- If users make different types of agreements with energy providers on the terms of the contract (time of delivery, service levels), how can the electricity grid manager guarantee sufficient capacity?
- How can we model and simulate Smart Grid Systems? Which modeling techniques exist for energy provision, in which the ICT system is incorporated? How could we use perfect knowledge on the system?
- Should the smart meter only register energy consumption and production, or also control appliances?
- Is energy supply sufficient for electrical transport? Can we manage scarcity?
- How can the interests of stakeholders be represented by intelligent agents, so that they can jointly negotiate their mutual interests?
- How do you communicate energy use to users in a comprehensive, yet attractive, fashion?

Communication technology:

- Which communication technologies are needed for the smart grid? Does fiber technology offer real advantages? Is the use of the power grid itself an option? Do we need one infrastructure, or several ones?
- How can ICT facilitate the efficient use of energy transport capacity? Is it possible to determine optimal loading of (connected) parked electrical cars?
- Which information do we want to communicate? Which part of the information is time-critical?
- How can we transport sets of data with different reliability levels within the same communication system?

Can fault-tolerant systems contribute?

- How can the life span of an energy system (long) and a communication infrastructure (short) be aligned?
- How can in-house information be transported with a sufficient degree of reliability, without new wiring? Is the electricity network appropriate for this purpose, even if this would also be used for other purposes? Could it be wireless?
- What is the transition trajectory from the present state to a communication system for a smart grid? Is there a standardization trajectory?

Conditions for implementation:

- Business models: How can a supplier of communication services generate revenues and profits by transporting small quantities of data with high levels of reliability?
- Privacy: How can we guarantee user privacy in a smart grid?

Proposed Actions and Opportunities

Actions

- A national Smart Grid research & innovation program like in Australia
- Construction of a (prototype) Smart Grid infrastructure test-bed.

Opportunities

- Climate KIC in the EIT. www.climate-kic.org
- NWO's Smart Energy Systems program: www.nwo.nl/ses

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Smart Mobility Systems

Introduction

Mobility of persons and goods is a key asset in modern society; in order to preserve and enhance mobility new mobility solutions are needed that guarantee both safe and sustainable 'throughput', in an environment-friendly manner. Wikipedia states: "Mobility is the ability and willingness to move or change". In practice, mobility is associated with various aspects

- Logistics - transport systems,
- Mobility of persons: being able to move around, taking a personal environment 'along'
- Tracking & tracing: tracking objects, RFID technology, virtualization of physical objects

Domain challenges

In the table below we give the prominent domain challenges.

Domain challenge	Description
Towards a sustainable mobility system, for people and goods	Moving people and goods takes its toll: in terms of fossil fuels, noise and particulate matters. Can we reduce unnecessary movements, or replace them with more sustainable ones? What are the commercial, legal and behavioral thresholds?
Reducing traffic jams, increasing system throughput	The average fill rate in logistics is 45%, the average car-to-car distance in the Netherlands lies below the average European distance (2 seconds). What is required to further increase the throughput? How do the various aspects (human in the loop, technology, commercial / legal) contribute to the current status quo?

Safety	Roads get more crowded, and are used by multiple modalities (pedestrians, bikes, cars, buses, trucks ...). Reduction of casualties is a key ambition of many European countries, and directions involve both technology as well as the human in the loop. For instance, car-to-car and car-to-roadside communication could assist in preventing accidents to occur.

Extrapolation: with the increase of people living in cities, all three challenges will only become more prominent. Together they form important cornerstones of a livable city.

Special constraints: suggested technical directions make clear that some important boundary conditions need be obeyed:

- Availability and reliability of information, in relation to potentially limited connectivity via mobile networks
- A sufficient level of inherent privacy of user generated data; a sufficient level of open access to data to stimulate service innovation and service eco-system
- Scalability of small-scale solutions

Trends and Solution directions

Current leading visions on mobility are:

- ITS (Intelligent Transport Systems): Navigation systems will develop into a full-fledged information system, with which the user has access to information about the traffic situation to be expected, can reserve and pay for parking places, can be given advice on his route and destination, all tailor-made for his situation and preferences. The car communicates with systems on the road and systems in the car. These systems can warn the user of special or dangerous situations and help the user to take action. In special situations, such as traffic jams or in emergency situations or on special lanes, the car will take over the driving from the driver. (IIP MAIS).

- Personal smart mobility: Multimodal, in real time informed and enriched travel information. A traveler with a journey from a to b, get's provided with modality suggestions (public vs. real-time information on deviations, congestion and other irregularities, relevant context information and extended service options such as reservation, billing and ticketing or presence information.

More specific trends:

- Intelligent cars/vehicles. This is enabled by the concept of 'Connected cars': car-to-car communication, car-to-roadside communication
- Automated Traffic guidance
- Multimodal route planning: integration of public transport in navigation systems
- Intelligent routing (in particular in the logistics sector)
- Congestion management: pay for use, incentives to change standard mobility patterns ...

Scenario Mobility 2020

Twenty years ago, the average Dutch citizen viewed traffic jams as an unsolvable problem, or even as a characteristic of the daily routine. This perspective changed radically in the second decade of this millennium. The possibility to choose reliable alternatives at any moment of a journey persuaded even the most convinced car owner. A recent crowd-sourced investigation by TNS NIPO showed that 80% of the respondents use on a daily basis at least two traffic modalities. Moreover, 50% indicated to use three or more! The most important drivers are the reliability of predictions of ToA (time of arrival) and the punctuality of the various public transport alternatives. The high percentages in the TNS NIPO investigation are remarkable because of the recently introduced cooperative driving mode on the main highways in the Randstad. Cooperative driving has improved the throughput (car-to-car distance decreased to 0.7 seconds) and the reliability, and has decreased the chances to end up in a traffic jam. In a twin-interview with the president of the ANWB and the minister for Mobility and Logistics, the former indicated that the tax on personal CO2 footprint should be viewed as the most important reason for this change in behavior. This tax addresses sustainability in the widest sense of the word and leapfrogs the controversial and hotly debated road pricing proposal from 2009/2010. The minister proudly mentioned the European award in the area of 'sustainable regulation', a price for implemented policies and regulations that stimulates sustainable behavior.

Use case scenario: Somewhere in the not so far away future...

It's Saturday, and Melanie wakes up with a smile on her face. Ever since the daily stress for traffic jams vanished, and her last resort-telephone calls to Harm to pick up Claire from OSC (out-of-school care) were no longer needed, Melanie can start her weekend more refreshed. And today is even more special - the whole family will have a day out at the Deventer book market. Her 6-year old son Pim works already for some days on his tablet to prepare a suitable travel scheme. This month at school is dedicated to 'sustainable mobility', and the various groups compete with their personal CO2 footprint for a mouth-watering price: a long weekend in 'the house of the future' in Almere, including a survival in the Oostvaardersplassen. Melanie indicated that she wanted to combine sustainability with relaxedness, and since Pim's sister Claire is only 4 years old, he should take careof a number of constraints ...

Two hours later, Melanie is enjoying a lovely ristretto in the newly build Utrecht CS Experience Centre - the Centre has been finished recently as the first part within the CU2030 plans of the city, and has already been nominated as the largest multi-modal transferium in Europe. Pim and his father have been able to combine their personal all-in travel-voucher with some nice surprises: a reduced price for the ristretto and for every member of the family a free e-book. Claire is playing with her 3D version of Cinderella. However, close to Apeldoorn the excellent mood disappears: the driver-avatar appears on the screens in the back of the seats, and indicates that the journey will come to an abrupt end. A cooperative driving vehicle on the loose has created havoc on one of the nearby crossings. Luckily, the Dutch railways are able to quickly provide an alternative: taxi-coaches. However, Pim objects to this alternative, since he will loose too many CO2-goodies... Using his tablet he finds a better plan B: the high-speed bus on the A1 makes an extra stop at the Apeldoorn-transferium, and will continue directly to Deventer. With a delay of only 5 minutes the family meets with the rental-bike owner in Deventer, and two minutes later they are cycling on their fashionable bikes to the book market...

Challenge and research questions for Mobility

The Mobility challenge is meant to stimulate the explicitation of research challenges for the Mobility domain, but also to provide focus and scope. Key focus is on the deployment of an ITS communications platform; a platform that enables sharing of data and information, thereby stimulating cross-sectored service development:

- services that enable citizens to travel informed, in a safe and sustainable way
- services that enable stakeholders (carriers, service providers, urban planners) to make optimal use of (shared) resources
- services that influence the behavior of travelers, in order to reduce the potential overload of the traffic system.

Research questions

The most important research questions are categorized as follows:

- *Realizing scalability:*
  - How to use spatial selectivity (e.g. using position dependent beaming with multi-antennas) to improve the efficient reuse of resources
  - How to manage distributed systems of variable size?
- *Striking the balance between ad hoc and infrastructure based solutions*
  - Efficient use of spectral resources for tracking and tracing
  - How to integrate the mobility and logistics domain with the IP domain?
- *Sustainable solutions: low-power / long life time*
  - How can we develop ultra-low power solutions for positioning (RFID and ultra low cost tags)

- How to develop intelligent tags, with more info, enabling two-way (send/receive) communication?

- *Realizing trust and privacy:*
  - Trust to enable domain-crossing cooperation and service development
  - Trust to authorize proper access
  - (Inherent) privacy to stimulate on the fly aggregation of information
- *(Technologies enabling) system innovation*
  - Charting market imperfections and unwanted control points that stale innovation
  - Realizing an inventory of standards and systems that could enable the various services
  - Data fusion for large-scale sensor systems
- *Towards cooperative driving*
  - How to take care that vehicles are able to drive closely together at high speed?
  - How to use broadband mobile (RF, wireless) communication for inter-car communication, anti-collision communication, radar, ...

Proposed Actions and Opportunities

Proposed Actions

- Multi-modal traffic guidance
- Experiments with car-2-road technologies, for instance in the Helmond testbed.

Opportunities

- Participation in FP7 PPP-Future [1]
- Involvement in the EIT ICTlabs activity around Intelligent Mobility and Transportation Systems [2]


1


2

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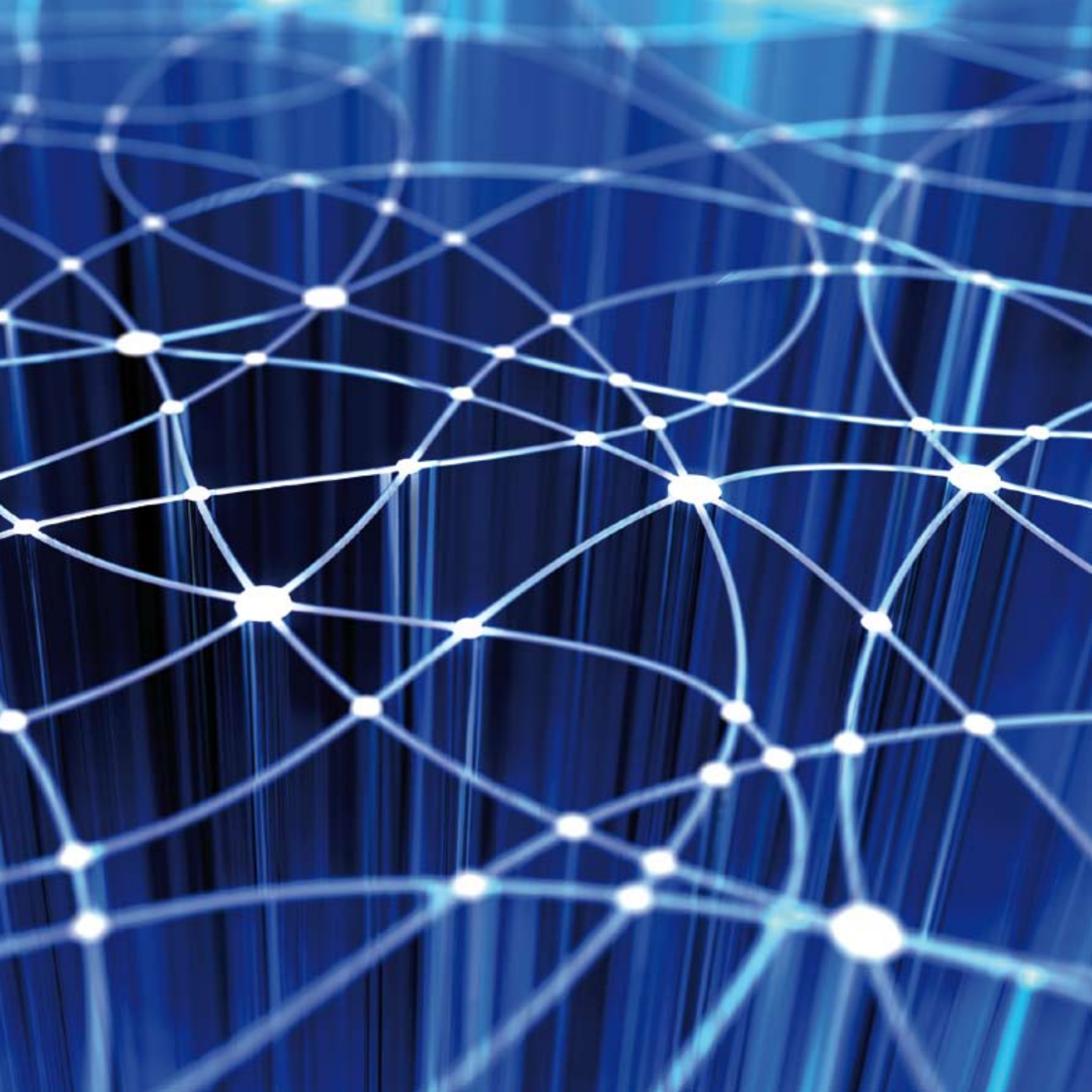

Cross-cutting challenges

Communication ...

Communication is the exchange of information between (groups of) individuals. In an increasing number of domains, communication is facilitated and mediated by technological means such as computers, portable devices, sensors, internet, and (mobile) network infrastructures. Communication technology is and will remain to be a critical factor in many economic and societal sectors, for instance health and well-being, entertainment and creative industries, mobility and logistics and environment and climate.

... is pervasive ...

Rapid developments of mobile and internet technology in the past ten years have led to evident changes in the way society interacts and business is done. Communication and computing are everywhere, from television sets to navigation systems, and from web2.0 to sensors in fashionable sports wear. The average modern citizen uses tens of communication devices on a daily basis, often without realizing it. Thanks to embedded systems and wireless net-working, we are reaching an era where technology is gradually disappearing into a pervasive fabric of communication utilities.

... yet is facing complexity challenges ...

Communication technology has long aimed at solutions for connectivity anytime, anywhere and anyhow. In sectors that are historically communication oriented, such as managed telecommunication and internet systems, the abundance of aptly called 3G-solutions (WLAN, UMTS, Bluetooth) gives an adequate answer to their connectivity needs. However, in newly emerging and innovate sectors - especially those that are emphasized as drivers for society and economy in the beginning of the 21st century - communication is still facing enormous complexity challenges hampering innovation across these sectors.

... for three reasons.

First, interaction between communication systems and its users is complex because it requires careful optimization between users, providers, applications and the autonomy of the supporting communication system. Second, communication technology no longer connects only people, but also devices. For example the "Internet of Things", a wireless and self-configuring network between 100.000 billion objects such as appliances, personal devices, and clothing. Or sensor networks for collection health, energy, or environmental data. The sheer complexity of these heterogeneous communication systems makes it impossible to get away with today's ad-hoc solutions, but a structured architecture and design is required. Finally, the behavior of these very large scale heterogeneous systems is hard to predict and therefore hard to control - especially in those cases where

the communication architecture is decentralized, such as in peer-to-peer and ad-hoc networks, and in networks of embedded devices. Yet these systems should be scalable and operate dependently and securely.

Intelligent Communication ...

With the term "intelligent" we denote communication systems that incorporate awareness of their heterogeneity and distributed nature, of their expected dependent and secure operation, and of their intimate collaboration with human users. The adaptive, intuitive, and robust (AIR) technology that is needed to achieve such intelligent communication differs radically from what is provided by state-of-the-art solutions since these often rely on fully managed and centralized network architectures. No fully functional intelligent communication infrastructure exists to date.

... is needed ...

However, an operational intelligent communication infrastructure is from a technical point nearly always silently assumed to be "ready for use" in sectors such as health and well-being, entertainment and creative industries, mobility and logistics, public safety and environment and climate. However the gap between the availability of technology and real use must be bridged urgently by joint efforts of research, development, and domain-specific valorization of AIR technology.

... and can be delivered.

The ICT Innovation Platform (IIP) Intelligent Communication seeks to bridge this gap. The outlook for Dutch impact and success in this domain is positive. The Netherlands are forerunner in high-end backbone and wireless/wireline broadband coverage. Experience with public internet is very high because of the open minded attitude towards early adoption of new technology. Stimulation programs such as GigaPort, Multimedian, Smart Surrounding, Freeband Communication have focused attention on relevant knowledge areas and have encouraged the formation of national centers of expertise.

Complexity

At present, communication, internet, sensor technologies and applications are integrated in an ad hoc manner. In the coming decades, these domains will merge into an integrated communication fabric. Even more importantly, however, is that this communication fabric will retreat into the background. People will no longer be bound to specific devices such as computers or PDA's. And computational intelligence and communication capabilities will be available and duplicated everywhere. This can be in television sets, navigation systems, mp3 players, sensors in clothes or walls, but also in a variety of sensing systems for instance for health, safety, and environmental monitoring. Compared to the present, the challenge will be much more on effective usage of available sensor networks and communication capabilities rather than on connectivity itself.

Abundance of intelligent capabilities

The communication and processing capabilities in the world surrounding us will be abundant and in most cases the different possibilities and choices for technologies, processing and services in the last and first meters of the communication chain will form a highly redundant system. In order to optimally deal with this enormous increase of complexity in the last and first meters we need a systems approach and new intelligent solutions.

The demand side

Experience of the past years has shown that innovators in application-specific domains increasingly try to implement new technologies and have a clearer picture what they want to achieve with new communication technologies. In practice, they still encounter many problems with respect to dependability and scalability of wireless solutions, integration with legacy and back office systems, lack user experience of applications, no suitable business models in place and the volumes of data communicated and stored. As a result, many innovations and inventions remain on the shelf, do not find their way into practice, or do not deliver the promised benefits. In addition, the diversity of the application domains and especially the diversity of all the individual applications and communication possibilities require focused attention on application-specific solutions. It is especially this diversity that puts the communications sector for major challenges.

Intelligent Communication Challenges

Summarizing, the challenges lie in finding intelligent communication solutions by...

- create domain specific solutions that are optimally suited for the intended purpose, with high user experience and viable business models.

- help us deal with the enormous complexity in the first and last meters of the communication chain

- help the Intelligent Communication sector to meet the demand for highly specific solutions at a reasonable cost.

AIR concepts

When analyzing the challenges for solutions within the diversity of the complex environments in different domains, there are three common and recurring aspects:

- **Adaptivity:** the overall system is aware of relevant context parameters and adapts to changing context and conditions in a self-aware manner.

- **Intuitiveness:** For the user the system shows the behavior and functionality that the user expects, nothing else. This requires careful balancing between autonomy of the system and the control and experience of the user. Intuitiveness also implies that the communication system does more than just moving bits: it connects people with their environment by providing them useful information and pleasant-to-use content.

- **Robustness:** overall system is sufficiently dependable and resistant to undesired changes, which may be occurring involuntarily (noise, errors, connection or power loss) or that may be due malevolent behavior such as security and privacy attacks, and malfunction.

We consider the next stage in communication systems the inclusion of intelligence. The central solution that the IIP Intelligent Communications aims for is to realize intelligence by making the communication environment adaptive, intuitive and robust. This can be achieved by providing both generic and domain-specific communication solutions that optimally utilize the available communication and computation resources.

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The editing team consists of four persons from the IIPIC platform: Patrick Strating (Principal Scientist, Novay, and IIPIC coordinator until April 2011), Henk Eertink (Fellow Novay, IIPIC directeur starting May 2011), Erik Fledderus (director of innovation - future internet use, TNO), Patrick Essers (program director Seedlinqs, Ericsson), and Jan van den Ende (Professor Management of Technology and Innovation, Erasmus University Rotterdam).

Appendix: the process of creating this SRA

In order to emphasize the societal relevance of telecommunications research, IIPIC chose to aim the SRA at three application domains: smart health systems, sustainable mobility systems and smart energy systems.

The co-creation process for the new SRA consisted of interviews with key players in the field. This resulted in the three selected application domains. Subsequently the IIPIC community discussed the domain challenges in a workshop held early 2011. The results of this workshop were edited online by the IIPIC community during the second quarter of 2011. In the third quarter the SRA was reviewed and finalized by the editing team.

Colophon

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