



# 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, Multimedien, 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.