eMobility

Mobile and Wireless Communications

Technology Platform

Strategic Research Agenda

Staying ahead with SET

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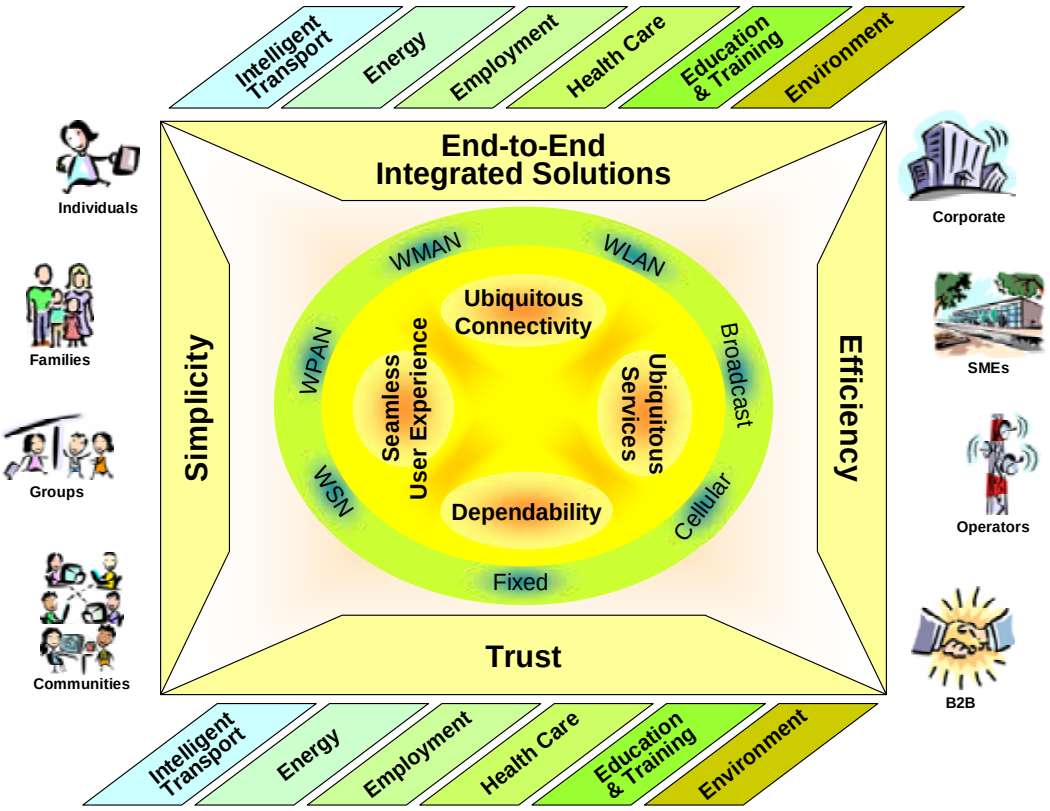

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List of Acronyms

AAA	Authentication Authorisation Accounting
API	Application Programming Interface
BAN	Body Area Network
BWA	Broadband Wireless Access
CAPEX	Capital Expenditures
CMOS	Complementary Metal Oxide Semiconductor
DMB	Digital Multimedia Broadcasting
DoS	Denial of Service
DRM	Digital Rights Management
DTN	Delay Tolerant Networks
DVB-H	Digital Video Broadcasting-Handheld
EC	European Commission
GHz	Giga Hertz
GM	Genetically Modified
ICT	Information and Communications Technologies
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
IP	Internet Protocols
IPR	Intellectual Property Rights
IS	Information Society
IST	Information Society Technologies
IT	Information Technology
ITS	Intelligent Transportation System
MBits/s	Mega bits per second
MBMS	Multimedia Broadcast Multicast Service
MEMS	Micro-Electro-Mechanical Systems
MIMO	Multiple Input Multiple Output
MPEG	Moving Picture Expert Group
M2M	Machine-to-Machine
NEMS	Nano-Electro-Mechanical Systems
NoC	Network on Chip
OMA	Open Mobile Alliance
OPEX	Operational Expenditures
OS	Operating System
PAN	Personal Area Network

PC	Personal Computer
PDA	Personal Digital Assistant
PN	Personal Network
PSS	Packet Switched Streaming
QoS	Quality of Service
RAN	Radio Access Network
R&D	Research and Development
RF	Radio Frequency
RFP	Request for Proposal
RFSIM	Radio Frequency Subscriber Identity Module
ROI	Return of Investment
RTOS	Real-Time Operating System
SDR	Software-Defined Radio
SIM	Subscriber Identity Module
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SoC	System on Chip
SPIM	Spam over Instant Messaging
SPIT	Spam over Internet Telephony
SRA	Strategic Research Agenda
TCP	Transport Control Protocol
UI	User Interface
WAN	Wide Area Network
WLAN	Wireless Local Area Network
WSDL	Web Services Description Language
WSN	Wireless Sensor Network
W3C	World Wide Web Consortium
XML	Extensible Markup Language

Executive Summary

By the year 2020, mobile and wireless communications will play a central role in all aspects of European citizens' lives, not just telephony, and will be a major influence on European economy, wirelessly enabling every conceivable business endeavour and personal lifestyle. The following sentence articulates the essence of the future aims and vision: **"The improvement of the individual's quality of life, achieved through the availability of an environment for instant provision and access to meaningful, multi-sensory information and content."**

Realisation of this vision demands a major shift from the current concept of "anywhere, anytime" to a new paradigm of "any network, any device, with relevant content and context in a secure and trustworthy manner".

The future systems will be complex, consisting of a multitude of service and network types ranging across Wireless Sensor Networks (WSN), Personal Area, Local Area, Home Networks, Moving Networks to Wide Area Cellular Networks. The increasing dependency of society on such communication infrastructure requires considerations of new applications and requirements into their design as well as new research methodology to realise them.

Research methodology proposed here is based on Europe's unique strength and approach to research and development of telecommunication systems. It is captured in a new concept called "SET Concept" that underscores the need for a 3-dimensional vision of research activities that will deliver Simplicity, Efficiency and Trust, strongly advocating "integrated" research and "end-to-end" solutions. The "Simplicity" is to enable simple use of services, services deployment and enhancement and simple and self-optimising operations, maintenance and upgrades. The "Efficiency" emphasises on efficient use of networks' all types of resources, whereas the "Trust" considers the new requirements and needs of modern societal dependency on use and full availability of such systems in carrying out their daily lives with robust security and resilience in face of variety of natural and man-made disasters.

Several strategically important technologies and non-technical barriers have been identified and justifications provided for their considerations into future national and European research programmes. The technological related chapters are complemented with newly identified applications from other industries needs and expectations from mobile and wireless technologies. Further work on "Flexible business infrastructures" is justified, demonstrating different business models and business interfaces that are envisaged in future.

1 Vision of the Future Mobile and Wireless Communication

By the year 2020, mobile and wireless communications will play a vital role in all aspects of European citizens' lives. The industry sector will contribute substantially to the European business prosperity. Technology will greatly evolve from the current concept of "anywhere, anytime" to a new paradigm of "any network, any device, with relevant content and right context in a secure and trustworthy manner". This stretches the art of mobile communications beyond radio and computer science into new areas of biology, medicine, psychology, sociology, human sciences and nanotechnologies. The following sentence articulates the essence of the eMobility aim and vision:

"The improvement of the individual's quality of life, achieved through the availability of an environment for instant provision and access to meaningful, multi-sensory information and content".

An **Individual** person is in the focal point and reinforces the idea that users will have a much stronger role in defining their own communication sphere, for example, effecting personal preferences independently of network, device, location, operator and service. This also means that network and service provision should be based on users' needs and interests, namely the establishment of group communications. User communities including; families, friends, friends of friends, and associates, are also considered, since communities activate people on a daily basis, implying availability and responsiveness. The increasingly important role of PANs and ad hoc networking will catalyse the emergence of online communities.

Improvement, in parallel with novelty, constitutes one of the basic reasons for R&D, i.e., the ultimate goals are achieved not only by inventing and proposing new things, but also by improving existing ones, which, in the end, serve as enablers for new products and services. However, one must also recognise the possibility of disruptions that can totally change complete businesses; disruptions will most likely also shape the face of communications and impose completely new business models in many cases.

Quality of life is a major human goal, and eMobility contributes to it beyond the very basic provision of a communication means. The starting point of future system and service design is a person's basic needs and interests, which span one's personal, family, professional and private

lives. Technology needs to improve the quality of life in terms of not only wealth creation, but also education, job skills improvement, health enhancement, security and safety. Machine-to-machine communications is an example to be taken into account, because it helps in increasing system intelligence and hides complexity and technology from the user. Furthermore, it is also about enabling and allowing European business to grow and prosper by building and fully utilising the communication environment.

Achieving through the availability implies tangible benefits through an integrated system made available. The user will pay for usage, devices and services, but the cost needs to be justifiable. Users might take things for granted, but this emphasises the need for security and trust. Furthermore, systems and networks should be waiting for the user, not the other way around, i.e., constant high efficiency. This leads to dynamic solutions, resource harvesting and borrowing. Seamless connection between private and public services, local and long-range communications, will be a major enabler in the future communications.

Environment means that the users will strongly interact with the environment that surrounds them, e.g., by using devices for personal use, or by having the location as a basis for many of the services to be used. This implies a totally different structure for the networks. Also context recognised by the system and it acting dynamically on the information is a major enabler for intelligent applications and services. This also means that sensor networks and RFIDs are increasingly important. The number of devices that people carry (knowingly or unknowingly) will increase. Furthermore, the increased interaction between devices will consume power. Therefore, the problem of power consumption, and the limitations thereof, will continue to be of importance.

Instant communication, as perceived by the user, is the essence of the game, in the sense that the user will be capable of communicating how, where and whenever needed, as well as, capable of using more than one system or network simultaneously to carry the information.

Provision and access carries the two-way communications as we know it, but it goes beyond that, as the users will be provided with and have access to content and information they want in a useful way, namely concerning transmission speed. In the future, much of the user information may, indeed, be local, as opposed to information that does not take location into account. Moreover, peer-to-peer communications will play a key role. The provision of, and access to the “right content” at the “right time” is perceptual, and should be provided when a user is ready to receive it, in a format that considers user privacy and present context, by using any available means and network. Sometimes the user requests the information, i.e., “user access to information”, while other times it is the “information that accesses the user”, based on user’s

personal or community profiles. The success of such a vision depends very much on simplicity of access and use of services and on operation of the devices. Another important factor is the cost of a service, which is the reflection of capital and operational costs of a network borne by operators and content providers.

Meaningful is key in the vision. On one hand, undesired information (e.g., unsolicited advertisements, spam, viruses) and privacy are growing challenges of today's communications. On the other hand, it means that information filtering is very important, so that the users really get what they want. The users need to be aware (if they so desire) of information and content that are of interest to them. The information accessed or provided to users has to be devoid of unnecessary, irrelevant and redundant components.

Multi-sensory is related to all the users' devices and surrounding environment cooperatively capturing a users' presence, context as well as virtual presence. Using such valuable captured information enables provision of services to a user based on his/her truly characterised context in an appropriate modality. This would enable service provisioning to a user as natural and private as interpersonal communications or direct communications in a non-invasive and context-aware manner. This extends the mobile and wireless communications beyond radio and computer science, into new areas of science, like biology, medicine, psychology, sociology, and nano-technologies, and also requires full cooperation with other industries not traditionally associated with communications. Finally, the information should be multi-sensory and multi-modal, making use of all human basic senses to properly capture context, mood, state of mind, and, e.g., one's health state. Clearly, the realisation of this vision of mobile and wireless communications demands multi-disciplinary research and development, crossing the boundaries of the above sciences and different industries. Also, the number of electronic sensors and RFIDs surrounding us is quickly increasing. This will increase the amount of data traffic.

Information and content signifies the growing importance and volume of data and information needed and provided relative to voice telephony. This vision cannot be complete without the definition of future application scenarios and users. A good starting point from which one should draw trends is to consider children and grand children as potential users. They will be the active population in the next 15-20 years' time.

2 Research Methodology

Many steps are required to turn the future vision into reality and from the establishment of this macroscopic vision, many tasks and challenges need to be identified, and solved, at the microscopic scale. The remainder of this document deals with this latter aspect, providing for each of the identified areas a specific vision, its rationale and objectives, together with a list of the research priorities. Besides these main areas, others that can be considered close to basic research are also identified, together with some initiatives that should be implemented as potential projects dealing with these specific areas.

It is not, however, sufficient to only define a list of isolated but strategically important technical and non-technical issues and projects. There is a great need to define a suitable framework providing a common and complementary research policy, goal and strategy. Adoption of this common research strategy by all projects within national and European research initiatives guarantees their outcomes to be complementary and of high relevance and value. Emphasising this in European research context is a new concept called the “SET Concept” that underscores the need for a 3-dimensional vision of research activities that will deliver **S**implicity, **E**fficiency and **T**rust.

2.1 SET Concept

The SET Concept is designed to overcome potential technical, business and psychological barriers to the adoption and acceptance of new technologies and services. It takes into consideration the interests of users, network operators, service providers, and manufacturers, and provides a challenging research agenda for all.

Simplicity - It emphasises research into new solutions for managing complexity seamlessly on behalf of service providers and for hiding complexity from a user in accessing, using and creating services. Complexity is delegated from a user to the communication system which must adapt to the individual’s life stage preferences and situation, and a variety of other contexts.

Efficiency - Solutions which result in efficient use of spectrum and network resources, and higher throughputs, through appropriate cooperation and adaptation techniques. The new target is not necessarily higher bit rates as in the past. Autonomous self organisation is needed to continuously operate at the optimum point under dynamically varying conditions, as well as capabilities to easily incorporate (as yet unconceived) future services and requirements.

Trust - Wireless communications will enable an always-connected environment, facilitating services to support private and professional life of individuals, families, and special interest groups. Intelligent services will be based on sensitive personal information, context and profiles traversing different network types, and multiple business and administrative domains. Any successful adoption and use of future services and networks in all walks of life, imposes the creation of a trust environment. This is necessary to overcome possible psychological barriers through building a sense of trust in the integrity, privacy, security of information and networks, as well as to protect society against malicious, criminal or terrorist activity.

2.2 Research Challenges

Simplicity

- Ubiquitous connectivity and session continuity through auto-connectivity between legacy and new types of networks: WSN, PAN, LAN, Home Network, Moving Networks, Wide Area Networks and techniques which facilitate self-(configuration, organisation, healing) and management of heterogeneous and dynamic networks and services.
- A network agnostic service execution platform that interacts with networks and terminals and also facilitates the deployment, adaptation and management of services on the various (including mobile) devices.
- Innovative services based on a user's ambient intelligent and streamlined context classifications methodology.
- Enabling techniques for user-created content facilitating peer-to-peer communication.
- Smart user interfaces and interactions with learning capabilities to evolve with a user interests and age, for all types of users and in particular elderly with emphasis on portable personalisation of services and networks.
- New mobile device form factors, included embedded wireless chip connectivity.
- Radically simplified mechanisms and technologies for context capturing, processing, distribution and integration into intelligent services.
- New and efficient search engines with automatic zero-configuration and complexity management (including the management of privacy and trust).
- Intelligent customer care and provision of smart support in real-time in case of technical difficulties.
- Seamless user experience for all age groups with emphasis on portable personalisation for both the services and the connectivity.

Efficiency

- Joint optimisation of coverage, capacity and quality techniques through cooperation and adaptation techniques.
- Efficient mechanisms for joint exploitation and operation of available diversities in time/space/frequency/code/power domains.
- Investigation of alternative deployment concepts and system architectures beyond the classical cellular approach.
- Efficient cross-layer operation and optimization.
- Intelligent resource (frequency, battery, power, hardware, software) discovery and management techniques.
- End-to-end content and media adaptation techniques such as time-shifting, intelligent catching, opportunistic transport/transmission, rate/quality adaptation.
- Centralised and de-centralised self-organising network topologies for both operator-based and operator-less radio access network concepts for special application areas (e.g., disaster relief and campus networks).
- Seamless convergence between fixed and mobile at both service and network levels, exploiting broadband optical technologies.
- Innovative transceiver architectures and jointly optimized RF and baseband hardware designs, matching the nano-electronics roadmaps and exhibiting new degrees of scalability, flexibility, security, energy-aware performance, cost efficiency and design productivity.
- Evaluation of Network Information theoretical limits of cooperative and self-organising networks and research into advance coding design and signal processing schemes to achieve these limits.
- Investigation of the impact of new frequency bands for future systems on the radio propagation and specification of appropriate output power levels to ensure compliance with relevant guidelines and regulations related to human exposure to radio frequency electromagnetic fields.
- New methods of frequency usage, coexistence, cooperation and sharing techniques for/between exiting and newly identified frequency spectrum and radio access technologies, based on cognitive and spectrum-agile radios to select the most appropriate radio access technology for a given environment.

Trust

- Secure data management, and synchronization and private exchange of user profile and context information.

- Efficient encryption and cryptographic mechanisms and algorithms suitable for different types of devices and networks.
- Identity management & privacy.
- Secure and dependable end-to-end network protocols and applications enabling a simple-to-use trusted transaction environment.
- Unified Digital Rights Management.
- Transparent and flexible Service Level Agreements.
- Combined multi-layered mobility support and authentication/authorization across diverse networks and support of simultaneous use of multiple access technologies.
- Secure software and execution environment including O/S.
- Device and network protection against (virus, trojan, DoS attacks) and intrusion detection.
- Safe and secure software download enabling networks and device re-configurability.

2.3 Mapping Research Challenges to Research Areas

Seamless User Experience for All Ages

- Smart user interfaces with learning capabilities reflecting the user needs and abilities
- New Mobile form factors
- Automatic zero-configuration and complexity management
- Efficient search engines
- Intelligent and efficient real-time customer care

Trust, Security and Dependability

- Secure and dependable end-to-end network protocols and applications
- Safe and secure software download mechanisms
- Advanced authentication techniques
- Robust, secure end-to-end self-(configuration, organisation and healing) techniques
- Metrics for TSD performance analysis

Ubiquitous Services

- Network and Device agnostic service execution platforms
- Ambient intelligence capture and awareness
- Innovative context-based services
- User created content platforms
- Peer-to-peer communications support

- Unified digital right management support

Ubiquitous Connectivity

- Auto-Connectivity between legacy and new types of networks
- Joint Optimisation of coverage, capacity and quality
- New deployment and self-organised system architectures
- Intelligent resource discovery and Management
- Multi-layered mobility management
- New network architectures and protocols for post-IP next generation internet
- Full delay tolerant networking
- Collapsed protocol stack into an efficient and minimum protocol framework
- Innovative transceiver architectures
- New coding design and signal processing for cooperative networks
- New frequency bands and Spectrum sharing schemes

New and Flexible Business Models

- New modelling approach and practises that includes worldwide stakeholders (both traditional and new)
- A practical modelling tool for helping understand what constitutes value and how value can be optimised and leveraged on a daily basis
- Prototyping and piloting vertical market-specific light-weight value-oriented networks
- Research into value networks based on non-monetary compensations (e.g., social agenda for end-users, brand lift for manufacturers and operators, etc.)
- Specific research into impacts of peer-to-peer mobile e-commerce
- Comparative techno-economic analysis of new competing radio technologies and their specific environments (e.g., local, wide-area, residential, sensor-based)

2.4 Building on Europe's Strengths

As was achieved with GSM, the SET Concept offers new opportunity for Europe to be the leader in adopting a holistic and balanced approach to realisation of the future mobile/wireless communication system. The SET Concept will result in efficient and usable technologies and was developed taking into great consideration users' interest/needs as well as recognising the important role of wireless communications in Europe's economy. The research programmes will need to be focused on enhancing the axis of research (Simplicity, Efficiency, Trust) in the SET Concept through innovative techniques and technologies and targeted towards a system that comprises multiple network types. The SET framework offers a useful means to measure the

relevance and output of research programmes, also facilitating faster standardisation processes and reducing time to market. Supporting measures to evaluate the evolving European policy environment against the SET framework are also needed, if effective and timely research exploitation is to be secured.

As a further step to ensure such exploitation, the most relevant research results should be integrated and demonstrated in an open infrastructure for research and education purposes that facilitates joint optimisation of different sub-systems under the same conditions. These include, for example, use of different and new frequency bands, new spectrum sharing methods, interworking and seamless mobility solutions, new security techniques, cognitive paradigms, ambient intelligence, and new usages and context aware services. This infrastructure is expected to act as a European showroom of advanced mobile technology and services highlighting achievements from leading projects, and an open testbed to host SMEs and students through partnerships with Universities, research centres and through international cooperation.

3 Seamless User Experience for All Ages

In the near future, mobile technologies will support people in their daily life in a flexible and non-intrusive manner, and become a part of the environment in which people fulfil their daily tasks. The instantaneous and on-demand ways in which users interact with mobile devices, and devices interact with each other, offer the possibility of novel approaches for providing services that are simply not possible with traditional server and PC-centric computing. Furthermore, flexible displays and printable electronics offer opportunities for new innovations, as current physical restrictions are gradually disappearing.

Ultimately, it is the overall user experience that drives the adoption of new services. The User experience is a widely used term in telecom but different people understand different things by it and also use it to mean slightly different things. One view would be “user experience” is a combination of *Utility, Usability, Aesthetics, Availability,* and *Offline* issues. Thus, service platforms and enablers need to match the growing needs of the users, which originate from a wide variety of different sectors, covering both enterprises and the consumers. A special target group for new services and experiences is the ageing population in Europe: within a decade or two the expected rise in population age will pose serious demands to the whole European economy. Another group is the business people, who could be considered as early adopters of new and emerging technologies – thus paving the way for mass-market solutions.

Removing barriers to mobile application experimentation will result in the development of a myriad of new end user targeted experiences and services that Europe can be well placed to take advantage of. To be successful in the marketplace, European companies need to understand users’ needs, and the interaction between users and the mobile information and communication technologies environment. This means that there is a requirement to involve the concept of the user from the very beginning of activities, and to an increasing extent to establish a user-centric design process that will enable user requirements to be derived in a systematic way.

The implications of the SET Concept to the seamless user experience lie within the users’ interpretation of simplicity, efficiency and trust. These are briefly summarized in Table 3-1.

Research Areas	SET	Contribution to SET concept
User experience and acceptance	S	For the user, it needs to be simple to arrive to the objectives that she sets out to achieve. Simplicity means hiding the underlying technology from the user and shifting seamlessly between accesses and devices without having the session break down.
	E	Efficiency translates mostly to the user to not having to wait for the services and finding easily the searched items. Any charges need to be related to the utility value and perceived value-add.
	T	Trust is key to the user, as it determines the willingness of the user to use the communication systems for obtaining the goals. The level of trust is related to the degree and amount of any personal data revealed to the system and the services used.
Smart user interfaces and interactions	S	The user needs to experience intuitiveness of use and familiarity with the interfaces that she encounters. The look and feel should stay the same when possible and any personalisation information needs to be stored in a private and pervasive profile.
	E	Efficient interfaces will only ask of the user the bare minimum, and learn from it so that the required interaction is also minimised in time. A suitable interaction mode is selected based on needs and resources available.
	T	Flexibility and fault tolerance create trust.
Future mobile device form factors	S	The new device form factors will minimise juggling between devices.
	E	Efficiency increases when it becomes possible to achieve more tasks with less unique devices.

Table 3-1 SET Concept and seamless user experience

This chapter identifies specific challenges that need to be fully addressed in realising the vision of eMobility from a user's perspective. These are:

- Understanding user experience and acceptance
- Provision of smart user interfaces and interactions
- Mobile device form factors

3.1 User Experience and Acceptance

3.1.1 Rationale and Objectives

The aim of involving the users in research and development processes is to create meaningful and useful products. User-centric research focuses on identification and design of relevant concepts, prototype development, and usability and feasibility tests. Researchers and developers increasingly recognise the need to cross the barriers of disciplines to create products that match the future demands of users. A more multidisciplinary approach to the development process opens up to new possibilities, perspectives and methods. The possibilities and constraints of

future mobile technologies and applications are dependent on user evaluations in the context of their everyday lives. Such research considers relevance to social and cultural practices and provides a framework for cross-European studies of variations in user's needs and expectations of mobile technologies and applications.

Key issue in the user experience is that the research should be done continuously: users' habits, trends, competences and levels of acceptance change over time. Likewise, the research and testing activities need to follow a dynamic process.

Improved and extended multimedia communication services – richer, higher quality, ubiquitous and context-aware, while being affordable – will be a key driver for eMobility and for the future communication infrastructures. One should understand the users' preferences and requirements regarding future multimedia communication services in different contexts, and map these preferences down to requirements on the underlying technology.

Incorporation of the above issues would impose new requirements on network configuration technologies, as well as, on mobile service design, creation and deployment methodologies.

3.1.2 Research Priorities

To expand research and development on mobile technologies to embrace a broader social and cultural context is a challenging task that requires direct involvement of users with wide range of requirements and cultural backgrounds and abilities, in the process of research and development. The testing of technical solutions in real-life settings can help bridge the gap between different disciplines, as well as, technological development leading to successful market implementation.

Accessibility for all is an important vision for future mobile solutions. This provides increased availability, access and usability of content and application for different user groups (e.g., children, disabled, elderly) through multi-modal user interfaces. New mobile technologies can overcome the digital divide and increase cultural, social and political participation and understanding. However, security and privacy issues need to be carefully handled due to potential deployment for surveillance and control purposes.

Contribution, cooperation and collaboration are key characteristics driving new types of user experiences, where user becomes a part of a community. Media on demand, rich communication, education, online games and other individual content, activity, and service contribution are based upon collaboration between users and activity-associated software agents. Collaboration and (user) community aspects may be main drivers for future services and mobile experiences, but

they still need to be understood better.

Users demand interactivity anywhere, anytime and with any device or associated to any service, be it, e.g., push or pull. If we define interactivity as whatever mechanism that enables the users to send or receive information, participate, contribute or communicate with any kind of service or with another user, interactivity is perhaps one of the most differentiating aspects and values which can be added to present and future services. To achieve the goal of adding interactivity to present and future services, it is necessary to research horizontal and standardised platforms to support the rapid creation and deployment of interactive services covering a wide range of scenarios (mobile TV, radio, etc.), devices, services and technologies (PSS, MBMS, DVB-H etc.). These platforms must consider aspects, such as:

- Enriching principal content (e.g., TV or radio) with auxiliary (e.g., interactive) content
- Rich Media capacities and interactive content production and adaptation
- Relations and synchronisation between principal content and auxiliary content
- Distributing and delivering interactive content on several devices
- Defining new and innovative interaction modalities including collaboration (e.g., user contribution and communities)
- Interfaces with operator infrastructures, content providers and with other agents in the value chain
- Standardisation (3GPP, DVB, OMA, MPEG)
- Location-based interactive services

Coming back to the fundamental user research questions, advanced technical solutions should be justified by users' needs and requirements in order to guarantee success. The fundamental questions that need to be investigated are:

- How to ensure and improve the acceptability of services? How to define "User experience" and what is the bench mark for assessing it? How to take into account the ageing population and their needs? How to address the needs of business users? How to involve the public sector?
- How to develop software production processes to fully take user requirements into account at an early stage? How to improve user-centred research methods to better answer the new research challenges – together with business people and software designers? How to find out and improve the measurability of the user-centred research results?
- How to enable natural human-system interaction, for access to services and use the devices?

- What are the users' preferences and requirements regarding future multimedia communication services – what is the influence of aspects like basic media quality, richness and accompanying information on perceived service quality for different contexts?
- How to provide in distributed and heterogeneous environments with many functional and business relationships a defined and adequate service quality to the end-users or the enterprise customers?

This whole research setting calls for strong participation and involvement of human sciences research community, where one collects and analyses needs and requirements from actual users and iteratively validates results.

3.2 Smart User Interfaces and Interactions

3.2.1 Rationale and Objectives

The user acceptance of services and systems is critical for their success. There, the user interfaces (UI) and interactions play a major role, since they are often the only part that the user sees – they are the display window for all future communication systems. The expectations are not modest: the user interfaces should be simple, self-explanatory, easy-to-use, multi-modal, intelligent, context-aware, situation-aware and adaptive.

In multi-modal UIs, interaction modalities depend on the context in which the device is used. Interplay between contextual and interaction modality is critical to facilitate seamless use of the device. Smart UI technologies for mobile will open up great opportunities to meet the needs of the mobile user on personal basis in terms of simplicity and intuitiveness of use and based on one's own preferences and interests profile. Also, virtual and augmented reality with future displays and input-output-devices enable whole new opportunities for user interfaces and more comprehensive interaction.

From the enabling-technologies side, context-aware applications are fundamental for future mobile applications and systems to provide rich and consistent user experiences. This requires also interfaces with learning capabilities and adaptation (content, interaction modality, user interface) based on the context and situation. The research and development challenge is to create a flexible context-modelling framework with efficient means of presenting, maintaining, sharing, protecting, reasoning, and querying device, user and network context information.

In this new environment, we will have multiple devices with differing capabilities that can automatically establish their local communication, and provide the user with multi-modal interaction with multiple services. Users will also need to access their services via an increasingly heterogeneous communications infrastructure, either via fixed communication links, but in particular via wireless communication links. Automatic, multi-modal, and simultaneous access to multiple services is expected to enhance the user experience and also minimise the user's effort needed to arrange the communication and allow the user to focus their attention on essentials. In the same way, contents (typically multimedia) will be accessed from different channels and devices, and the user experience will be enhanced if these contents have the ability to adapt to device and context limitations, in a transparent way. However, the multi-dimensional heterogeneous usage environment poses several important challenges with respect to zero-configuration and hiding complexity from the user. Machine-to-machine communication and sensor networking technologies and RFIDs are also required to enhance the future user experience. When devices can communicate in an invisible, secure and trusted manner to simplify and make life more convenient for the user, they can significantly contribute and add value to life.

The borderline between the technologies that deal with interaction with the user and the underlying enabling technologies is not a clear one. In order to meet the multiple challenges, the user interface and interaction technologies research and development have to be coupled with the underlying technologies and platforms. The user-driven approach needed in designing new user interaction solutions poses new demands for the whole software and systems design and engineering process – co-design and collaboration is needed in a multidisciplinary fashion.

3.2.2 Research Priorities

Key challenges in user interfaces and interaction are to be able to design simple and natural multi-modal user interfaces (voice command, text to speech, gesture recognition) with enough features for different users in different situations. The interaction mechanisms should make use of all senses and modalities in communicating with the user – speech recognition as a starting point. In particular, 3GPP and ETSI have developed an intense standardisation activity for the promotion of speech-enabled services over the last years whose benefits must be reaped in the near future.

The systems and user interfaces described above should be able to adapt to the expertise and capabilities of the user, as well as to the context and situation of the user (exploiting all kinds of sensor information). In general, this requires systems and interfaces with learning capabilities and adaptation (content, interaction modality, user interface) based on the context and situation.

Specific important aspects within this context-awareness and adaptivity challenge are privacy and security; i.e., ensuring that persons' data do not end up in wrong hands.

Devices and services with autoconfigurable and interworking interfaces complement the list of main user interfaces and interaction challenges by enabling zero-configuration and hiding complexity in multi-dimensional heterogeneous usage environments.

Enhanced rich-media services are those services which aggregate in a single interface any kind of content (graphics, text, audio, and video) and client server real-time interaction. Rich media technologies will contribute to the creation of improved multimedia services in different contexts as it addresses some key characteristics like interactivity for driving new types of user experiences. Research challenges in this area include:

- Identifying services in which rich media technologies can add value improving the user experience (mainly from the point of view of interactivity)
- Defining and developing rich media value added services
- Contributing to standardisation and optimisation of rich media and enhanced rich media services (with W3C, MPEG and OMA) in those aspects not covered

In summary, multi-modality and context-awareness in user interfaces create fundamental research challenges leading to better user experience. Some major ones are listed below:

- Explore how context-awareness can provide rich and consistent user experiences for future mobile applications and systems
- Define architectures and technologies to provide access to contents, which are transparently adapted to device and context
- Invention of radically simplified mechanisms and technologies for context capturing, sensor communication, context classifications and new efficient and robust user-centric application design processes based on better understanding of usage model of services and devices
- Enhance current user interfaces with learning capabilities and adaptation (content, interaction modality, user interface) based on the context and situation
- Study the interplay between contextual and interaction modality for seamless use of the device irrespective of the access network
- Research new interaction ways and modes together with virtual and augmented reality technologies, future displays and other input-output-devices, and bring new opportunities for user interfaces and more comprehensive interaction
- Enable automatic zero-configuration and complexity management in order to make it easy and simple for users to find and utilise services with minimal effort

- Mechanism for evaluating and ensuring user's acceptability of UI's for example speech recognition

3.3 Future Mobile Device Form Factors

3.3.1 Rationale and Objectives

So far, mobile device design has been limited because of materials and communication technology limitations; for example, display devices have suffered limitations in size and resolution, and mobile devices themselves have been mono-block units with certain similar components (display, electronic components inside, etc.) limiting the innovations in design and functionality.

New manufacturing materials and methods – including flexible displays and printable electronics, open new doors not only for innovation but also for new ways of enhancing the user experience. The disappearing computing paradigm may become closer to a normal user, if her devices or their components are, e.g., being integrated into the clothes or other wearable materials without adding to the bulk.

Another dimension driving the form-factors, is the way people use their devices: are they for a single purpose or for multiple purposes? Is there one device for private life and professional use? Should one give more emphasis on small size compared with feature-richness?

3.3.2 Research Priorities

The form-factors research includes:

- How the new devices can help getting the best possible user experience in the future communication systems environment?
- New devices: design and impact of new materials
- Multi-purpose vs. single-purpose devices
- Distributed devices (including sensors and RFIDs)
- Usability and simplicity of the new devices
- Displays

In eMobility, future mobile device form-factors research is strongly connected to 'User experience and acceptance' and 'Smart user interfaces and interactions' areas. Within the former, one studies more the non-technology-oriented aspects, while in the latter one can cover the more technological interaction and interface possibilities.

4 Trust, Security and Dependability

4.1 Vision

Mobile and wireless communications will deliver an always-connected environment, facilitating secure and dependable services to support the private and professional lives of everyone. All stakeholders in the business value net - end users, the service or content providers, operators - need to be able to trust the security and privacy offered by the ICT services and the whole supporting environment. Users are protected from security and privacy threats at an adequate protection level that takes account of usability and cost. The use of security, privacy and trust solutions is designed in a way that as little as possible configuration or intervention is needed of the user.

This vision calls for an integrated, trustworthy and interoperable security and privacy architecture, in connection with well-defined and holistic security management services as a part of mobile service life-cycle management. Correctly designed and implemented security and privacy solutions enable the provision of new, advanced mobile services.

The security and dependability architecture will strongly support the **SET** concept. Solutions within the architecture should be **S**imple, **E**fficient and highly usable since hard to use and inefficient security solutions can themselves give rise to security vulnerabilities. **T**rustworthiness and dependability of security and privacy solutions is a necessary and central requirement.

The eMobility strategy for Trust, Security and Dependability (TSD) should be managed as an integrated component of an overall European Security and Dependability Research Agenda and kept consistent and coherent with applicable developments in other European Technology Platforms.

4.2 Rationale and Objectives

Technology convergence will be a key driver of the evolution of wireless communications towards eMobility. The converging industry sectors (e.g., internet and IT, infotainment, mobile communications, consumer electronics) carry a different history on security perspective and technical solutions. Therefore, security should integrate and evolve the existing security technologies through open standards in order to meet the requirements of the future advanced service products. A challenge for security engineering will be the convergence towards an IP-like common infrastructure that will introduce its own risks together with increased scope for existing

threats to propagate. At the same time as this convergence, access and device technologies will become more diverse and heterogeneous as new technologies come on stream.

From the security management point of view, we have already acquired irreversible dependency on the ICT systems that have already been developed. The global interconnection of networks and development of information technologies has added hazardous, multiple level international and societal dimensions to the vulnerability of ICT systems. The span and complexity of the European and global information systems will continue to grow and the information society is becoming ubiquitous but also more fragile and vulnerable. A vast number of interdependencies are progressively being built between the various information and communication systems and the diverse areas of social and economic activity, such as administrations and their legal infrastructures, finance, energy, transportation, health, security and defence.

A holistic perspective to the system and security design is clearly needed that integrates the set of common and interoperable technological security solutions. As part of this overview, it is extremely important to understand the cross-relationships between different security multi-disciplinary risk factors that can be generated by the always-connected environment and the interconnection of equipment and services, which were originally designed as standalone. A great challenge for the future security framework is to maintain simplicity and efficiency, avoiding computationally and complex implementation solutions, which instead would put enormous burdens on the users.

The role of security is essential in all parts of the future network architecture. Security should be integrated into the operation of the terminal, the radio access network, the core network and the service platform and in all relevant layers including hardware, operating systems and protocol stacks. Secure and dependable end-to-end protocols should be developed to meet changed requirements. The level of offered security should be adapted to the needs in terms of user authentication, authorisation, confidentiality, integrity, non-repudiation, privacy, anonymity, global identity management, and content protection. Security-critical applications like m-payments, m-health, content distribution and user profile management, are expected to drive the evolution towards an eMobility security framework. The required level of security depends also on the context and special needs of stakeholders. The overall challenge is to maintain seamless, context-aware and transparent end-to-end security with an array of different technologies combined in a multitude of combinations in order to provide a flexible and efficient framework for the users to securely and privately enjoy their applications in comfort, while ensuring the trustworthiness of all services.

In addition to security technologies, strong attention is needed on the required functionalities for security management as a part of life cycle management of mobile infrastructures, products and services. There will be no security if there is no security management and even good technological security solutions are unusable without security awareness of all stakeholders. Security technologies support the operation of the actual management, which, in turn, should be as automated as possible. In particular, end users cannot be required to carry out complex security procedures. Attention should be paid to supporting crime and fraud prevention and detection in networks and services. Security threats in future services might also have implications to the relevant regulatory and legislation framework. Research efforts and results should be taken into account when reviewing the regulatory framework for electronic communications.

The concept of trust will become more essential in the near future. We should be able to build trusted systems, trusted devices and the communication itself has to be trustworthy. There is a need for solutions that provide justifiable trust that the system or device will function according to its specification. Systems should also be adequately dependable – available when we expect them to be, and highly resilient and provide rapid recovery and resumption of service in the case of disruption or damage. It is important to note that many systems can be used for non-critical applications, but adequate trust and dependability should be assured for critical applications in the same systems.

The eMobility vision will evolve the business model by including a wide range of business players (e.g., terminal manufacturers, operators, service providers, content providers, hot spot operators), which will constantly interact even in real time in order to achieve the delivery of attractive user services. The stability of such a complex and demanding value constellation requires a trustworthy transaction framework, which will ensure appropriate interfacing between a large number of business players. Trustworthiness depends on adequate provisions of security throughout the chain of communications and its environment.

Privacy is an inherently important part of the user's trust in mobile services. From the point of view of service providers and service developers, correct and careful response to the requirements for privacy is imperative: inadequate privacy solutions will lead to lost opportunities and serious financial implications.

4.3 Research Priorities

The research priorities of eMobility trust, security and dependability include the following technical and security management items:

- **Holistic analysis, the "big picture":** Analysis of multi-disciplinary security threats rising from convergence of devices, services and connections is a constituent activity needed in the design of the future network architecture. Adequately and proactively carried out security analysis will be needed at all design phases from conceptual analysis to implementation.
- **Policy and TSD management:** Particular challenges are raised by the ubiquitous, pervasive mobile environment: the dynamics, fluidity, and mobility; the polymorphism and heterogeneity; the need for automatic negotiation and agreement of security policy and implementation to enable co-operation and collaboration of domains.
- **Proactive TSD solutions at architectural level:** Trust, security and dependability aspects should be integrated to the architectural decisions of future polymorphic communications systems already in the concept phase, not as an "add-on". Global, coherent and comprehensive solutions and architectural decisions are needed. The architectural solutions for TSD should span the conceptual level, for high level design, modelling, and policy making, and the technical level relationships and communications between the architectural entities.
- **Functional requirements:** Secure self-configuration, self-organisation and survivability (self-healing) are important functional requirements in the future network architecture. Dynamic transition and reconfiguration of devices and services set challenges to security and dependability management.
- **Security mechanisms:** The future network architecture needs to contain evolved protection mechanisms in the areas of: authentication and authorisation, confidentiality, integrity, non-repudiation, privacy, anonymity, identity management and content protection. Design of security mechanisms should take the context into account adequately. In addition, important design goals for security mechanisms are seamless interoperability and attack resistance.
- **Trusted devices:** The end-user device will have an essential role due to the direct user interaction, the support of application software and the connectivity it will provide to various access networks. The ubiquitous, self-organising and heterogeneous environment brings many new security concerns into the picture and new measures are needed to protect the devices and data stored in them or accessed through them. Multi-modal and context-aware authentication and context-aware authorisation can be used in ubiquitous world security implementations. There is a need to move up from the current paradigm of authenticating the device to the system into actually authenticating the user. Safe and secure software download mechanisms as well as trusted execution environment are important areas for development. Trusted and dependable software, functionality and execution and trusted protocols are in focus.

In addition to the directly technical research priorities, the following research priorities are essential from trust, security and dependability point of view and should be considered in parallel to the technical design:

- **TSD engineering:** Trust, security and dependability engineering is carried out throughout the product, service and infrastructure life-cycles. Advancement in TSD engineering methods, technologies, tools and practices is an important objective in the process of building trusted infrastructures and components systematically. Feasible business-aligned TSD metrics should be developed to support various activities of development phases of product, service and infrastructure life-cycles. Especially R&D phase (modelling, requirements engineering, architectural design, implementation and validation) would benefit a lot of a well-defined and well-balanced collection of metrics.
- **User perspective:** Commercial success of the eMobility vision depends heavily on user trust and confidence. In this context, the user needs should be taken into account in any relevant research activity while user trials should be exploited in order to capture the user perspective on security aspects. Secure data management, synchronization and enough privacy are important design goals. Usable, reliable and interoperable privacy and identity management solutions are clearly needed.
- **Future business models:** Issues related to secure transactions between business infrastructures need support of advanced services including multi-business information security management issues, and technical information such as exchange of sensitive information like charging, accounting, user profile data, user location, context, etc. In addition, technologies that enable secure and trusted transactions among multiple business players are required. The role of brokers responsible, e.g., of security and privacy management (trusted certificate authorities) in certain networks and services needs to be understood. Security management of future communication systems should use an interoperable set of security policies.
- **Regulatory issues and legislation implications:** The research activities can provide early detection of regulatory and legislation issues which may include, e.g., recognition of modern security crime, adoption of security technologies as a trustworthy basis for treating sensitive information (e.g., user's private data). Implications to legislation need to be studied. Global regulatory and legislation activities must be studied and taken into account.
- **Reactive TSD solutions (defensive and forensic mechanisms):** Complementary to the protection provided by the *affirmative* security mechanisms, above, defensive mechanisms and processes are needed for detection of and response to certain attacks and malfunctions. Nowadays, there is ongoing provision of protection against malicious

agents – such as viruses, worms, Trojan horses – and denial-of-service attempts. Most of malicious agents are dependent on inadequacies in widely-used components. In addition, defensive measures are required to detect and counter against intrusion and disruption attempts and other emerging threats, as well as unforeseen or unauthorised by-products of otherwise legitimate functionality. Design of the protection of the system operation and services must also include attack-resistance and fault-tolerance. Note that the defence strategy should include the ability to learn quickly to determine what it does not know and must include the allowance for what it does not know.

A number of trust, security and dependability (TSD) research topics are relevant to the whole digital environment. They include fundamentals such as ongoing cryptographic research, including flexible and scalable low-cost cryptographic protocols and security mechanisms for low power devices, the general issues relating to identity and privacy provision and management. The topics addressed by eMobility are those that are specific to mobile and wireless, or have some particular aspect or dimension.

Closely related to the individual and business need to control and protect their own information, is the requirement to protect and to grant rights to commercially valuable digital assets and intellectual property. Digital Rights Management (DRM), content protection and protection of digital assets will be an integral part of communication systems.

5 Ubiquitous Services

5.1 Vision

The potential separation between business related to access provisioning, and business related to services brings about new business models and challenges in ensuring their profitability. The agenda for future services includes creation, adaptation, hosting, provisioning, configuring, and their role in improving the quality of life of the individual(s) who are part of a dynamic and interacting society. In order to realise this, a total of four orthogonal but complementary research challenges are identified as research priorities (RP) and explained in more detail in the rest of this chapter:

- Innovative services (IS): user services that change the quality of life of the individual in a sensor-filled, dynamically changing and interacting environment
- Service Creation process Environment (SCE): realise and ease the creation of services and decreases the time-to-market
- Content and Media Creation (CMC) and adaptation: improve information and content and make available services instantly on various terminals
- Service Execution Environment (SEE): realises the heterogeneous service execution platforms and takes into account the IT and telco convergence, multi-domain operation, network and technology heterogeneity, global roaming and specific requirements for adoption by the industry

The limitations of the service platforms, devices and services of today are main drivers for seeking solutions of tomorrow, working towards convergence of the various network domains, depicted in Figure 5-1.

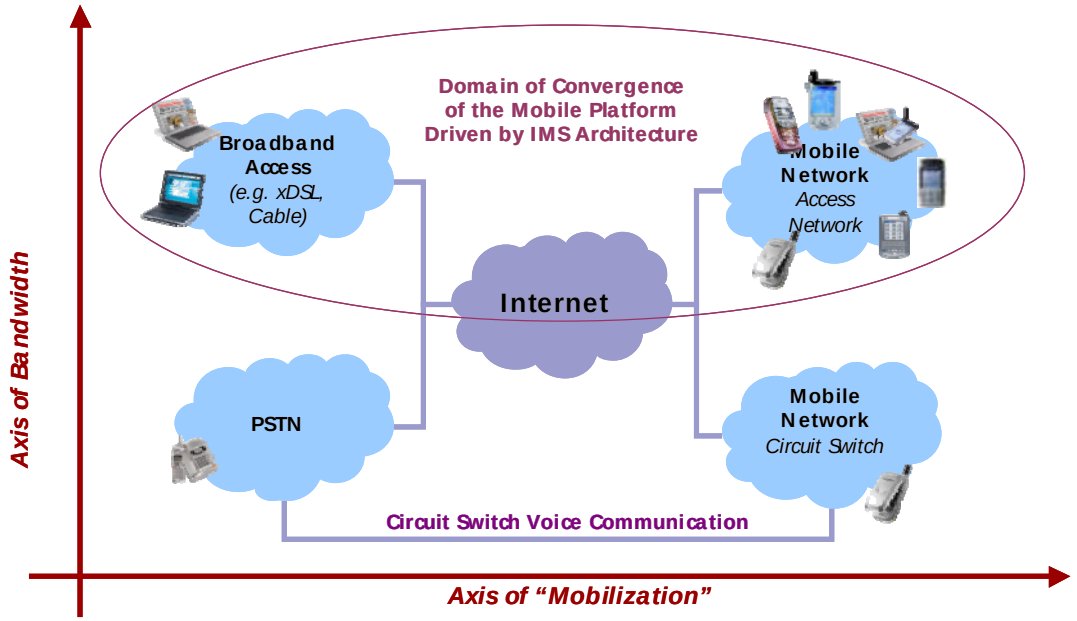

Figure 5-1 Trends in Service Architecture: The Telecom Evolution

The following table (Table 5-1) explains how the Research Priorities (RP) introduced in the following sub-section are contributing to the SET concept.

Research Areas	SET	Contribution to SET concept
IS	S	The research priorities identified in this section will simplify the use of services and the devices enabled by new of type of services that understand the user requirements and capability and adapt to their characteristics (e.g., behaviour, preferences and context) automatically and also hide complexity from them through auto-configuration and software updates of user terminals.
	E	In provision of user services the capabilities of users and their devices should be exploited in determining communication resources needed.
	T	Besides the information security and user's profile privacy it is important to provide a feel of trust to user in using the networks through provision of some level of control over use of their profiles and context.
SCE	S	Provide service creation environment that are more easy to use, even by non technical actors encouraging new players in the

		market of service and content creations
	E	The service life-cycle should be shortened and time to market shrunk. The RP should provide solutions for automated deployment, client generation over heterogeneous terminals and (semi-)automated service generation. The whole service creation process will gain in efficiency.
	T	Provide a trusted and controlled framework for accessing and sharing of service components by different actors involved in the service creation process.
CMC	S	Better user experience as far as accessing to Content and Media is concerned using context-aware and user-centric content delivery.
	E	Increased efficiency through the use of user terminal capabilities and an optimised use of the available communication modalities.
	T	By delivering the right content, to the right users, at the right time thereby enhancing the feel of trustworthiness and dependability by the users.
SEE	S	The creation of intelligent user-centric services will be facilitated by the availability of intelligent enablers at the SEE and SCE side.
	E	Efficiency in executing services must be provided both at the servers and at the terminals. Also, an efficient service execution environment that provide users with a large set of intelligent mobile services has the potential of largely increasing the efficiency of users in performing their daily tasks.
	T	Service execution environments are responsible of guaranteeing safety, security, privacy, and reliability in accessing and executing the services provided to the users. Their contribution to the trustworthiness of the overall platform is crucial.

Table 5-1 SET and Ubiquitous Services

5.2 User Services

5.2.1 Rationale

The user's communication environment becomes ever richer and is generally composed of various terminals that may vary (e.g., PDA, Laptop, PC, Mobile, embedded computer in vehicles, communicating objects) dynamically depending on the user's context (e.g., home, work, leisure, vacation, static or roaming). The communication and computation capability of this communication environment is increasing, enabling then the emergence of new brand of innovative mobile services.

5.2.2 Objectives

In order to provide people with the best possible service experience, the set of surrounding pieces of equipment is to be transformed or abstracted into a communication environment that can be easily accessed and used by the technology-agnostic user. To do so, the complexity the terminal capabilities and the heterogeneity of the underlying networks are to be hidden to the user. Assisting the users in such a way they can exploit this inherently complex communication environment without any prior technical training is mandatory to foster the adoption of new equipment, and consequently new services.

Assuming the richness and ubiquity of the communication tools available today, the available bandwidth, and the variety of contexts in which they can be used, a new brand of really innovative services is expected to emerge. Moreover they are expected to answer realistic user's expectations. The new innovative mobile services will have to be intelligent enough to:

- Understand the total situation or context attached to a person (or a group of persons)
- Behave accordingly either reactively – meaning that a context change has been detected and that the service adapts accordingly its behaviour – or pro-actively – the service detecting in advance something the user is not aware of and proposes to adapt its behaviour accordingly
- Anticipate the end-user's goals and intentions
- Optimally exploit the communication capabilities available at the user side for easy of use

This domain of mobile intelligence offers a wide landscape of new possibilities driven both by new mobile equipment capabilities (e.g., sensors, connectivity, multi-media support) and new related usages.

5.2.3 Research Priorities

The research priorities of user services include:

- Personal and mobile gateway automatic configuration mechanisms
- Data management and synchronisation in combination with the growing awareness of context: How to manage the huge amount of user information? How and when to select the most appropriate information according to a given situation? How to handle the underlying complexity before presenting to the user? How to migrate this complexity across different domains and across different terminals and devices? How to fusion different sources of information into a single one?
- How to provide the user at any time and any place with the most appropriate data and service environment?
- Intelligent customer care or how to provide smart support in real-time in case of technical difficulties?
- Improve the service experience understanding and quantifying the quality of experience. This includes understanding the requirements regarding future multimedia communication services in different contexts, possible de-compensation of components to study effects; the influence of aspects such as basic media quality, richness, accompanying information on perceived service quality for different contexts
- New middleware layer supporting the remote execution of services within the communication sphere (exploiting the best of communication modalities, communication channels and execution capabilities available at the terminal side)
- Proposing automated context-aware and semantic-based robots or agents (e.g., mobile reflexes and dynamic services) that provide pro-active or on-demand seamless support in various situations of the daily life
- Proactive services not only taking into account the mobile end-user environment (including the end-user's activity and role) and changes therein, but also able to anticipate predicted (or foreseeable) changes therein. Moreover also anticipating end-user’s intentions and goals
- Multi-modality and augmented reality enabled services that enhance the ways to use mobile services via smart sensors, distributed media restitution and aggregation facilities
- Reasoning capability: while a huge amount of data is available through sensors and devices, and huge amount of information is available, e.g., on the World Wide Web, there is no real flexible way to infer knowledge, i.e., interpreting these data and information according to a given domain (for instance transport or medicine). Research is needed to provide :
    - Large-scale reasoners ready-to-use by mobile application making then benefits of this mass of available information;

  - Light-weight reasoners usable on handhelds ;
  - Combinations of knowledge and data based reasoners;
  - Reasoners capable of handling superfluous, incomplete, ambiguous, vague and uncertain information.
- Managing in an efficient way the huge amount of information either gathered (or pushed) by (to) the user allowing an efficient and accurate aposteriori retrieval of information (knowledge base management, automatic knowledge clustering, contradiction and validity period checking)

Succeeding in this direction is not independent of concerns related to the service architecture. Thus, implicitly new mobile equipment are now not only terminals but mobile gateways as well, with the related issues of capabilities-discovery and automatic configuration. The value brought by the combination of such intelligence along with a diversity of mobile devices may lead to enhanced services and usage for general-purpose end user, as well as, vertical markets (e.g., health, transport, retail, tourism).

5.3 Service Creation Environment

5.3.1 Rationale

While it is foreseen that more and more companies will get involved in the service creation business, it is quite obvious that for profitability concern, the proposed services are going to target the largest audience possible, ignoring then services that are of interest for just a few people. As a matter of fact the service creation power has not been pushed in anyone's hand as the web page creation has already been for a long time. Easy-to-use creation environments (at home or on the move) are therefore needed to enable all users making their own customised services. At the same time, while competition increases, it becomes more and more crucial to decrease drastically the time to market, especially from service creation to service deployment. Then not only the average end-user is concerned with service creation, but the professional is, as well.

5.3.2 Objectives

In contrast to the radio and network technology evolution, with innovation cycles of up to one decade, the design phases and innovation expectations on mobile services are much shorter. Upgrades every few months and major service launches every couple of quarters are commonly expressed expectations already today. Standards in this area are developed iteratively by partner alliances and active involvement of the open-source software developer community. Introducing systems and methods that permit the maintenance of this pace of constant mobile service innovation and rapid time-to-market will lead to a sustainable competitive advantage for the

mobile industry. Making novel mobile service creation environments inherently aware of the underlying communication network characteristics and the users' mobile device capabilities will lead to a competitive edge for the European mobile service and network business.

A drastically simplified service creation-, testing- and deployment process, in a merged information technology and telecommunications world, will present one of the biggest challenges required to make the approach pervasive and the vision of ubiquitous intelligence a reality.

In contrast to current information technology style service creation tools and processes, a mobile service creation environment demands, in most cases, on-line test facilities, utilising network resources from different operators and data sources from multiple content providers. Today, no systems or methods are in place permitting the thousands of software developers, with a background in information technology, to participate in the mobile service creation process. This innovation and business potential is largely untapped, as of yet. The initial efforts made in the 6th Framework Programme need to be substantially expanded during the 7th Framework Programme to rapidly change this situation.

5.3.3 Research Priorities

In order to foster the mobile service creation and deployment business, essential research challenges need to be addressed:

- Research and develop **open mobile service creation and deployment concepts and environments** that do not depend on a specific execution platform that could become unfavourably dominated by a single organisation
- Investigate how the **standardisation processes** can be organised to meet the time-to-market demands of the service innovation life cycles in a competitive environment
- Study the potential of **overlay network technologies** for bridging and inter-operability between different platform solutions from different vendors, as well as, legacy solutions while still permitting independent system evolutions
- Examine how **mobile service creation environments** could be designed to leverage wide-spread **information technology style development tools**, while taking the mobile network specific characteristics and the multitude of mobile terminal capabilities and design factors into account
- Research **mobile service creation methods** that avoid the parallel development of service instances for all types of devices and all types of data transports
- Investigate and prototype **network support functions** that permit the creation of situation-aware services, while still keeping the mobile service logic slim and suitable for mobile devices with their limited processing capabilities

- Explore how **Web Services technologies**, automated code generation tools, XML based data, interface and interaction description languages can be enhanced to permit on-the-fly integration of platform features, services, access networks and devices
- Research **generalised user interface description methods and languages** for fixed and mobile services that permit an automated and on-the-fly generation of mobile device specific clients (like WSDL for service invocations today). This would greatly speed the mobile device and service innovation cycles. Personalised and device-specific user interfaces could be automatically generated once newly designed mobile terminals are introduced into the network and a first service invocation takes place
- Study techniques for **semi-automated composition of services**, based on pre-existing sub-services and network support functions

Assuming that thousands of skilled software developers start creating mobile services for all types of devices and networks, questions such as the following will be asked:

- How can large numbers of developers be provided with online testing facilities in **multi-operator environments?**
- What **business, security and software verification measures** have to be put in place to permit this mass service-creation to emerge?
- How can successfully tested new services be **rapidly deployed** to investigate their usefulness and business potential?
- How can **plug-and-play deployments** of new services be supported from a system design perspective?
- How can mobile service entrepreneurs be supported by automated value-sharing relationships?
- What types of **protection mechanisms** need to be put in place to prevent abuse of a simple and flexible service creation and deployment environment? What new types of business models and relationships could emerge?
- How can such a simplified mobile service creation and deployment environment be used to **gain a knowledge step** for the European society?
- Based on this knowledge step what measures need to be put in place to sustain and further strengthen the competitiveness and the European leadership in the mobility-enabled IS and IT domains?

5.4 Content and Media

5.4.1 Rationale

Improved and extended multimedia communication services (e.g., richer, higher quality, ubiquitous, context-aware and affordable) will be a key driver for eMobility and the future communication infrastructure. Multimedia communication services use digital techniques for capturing, encoding, transporting, storing and rendering information of any form (e.g., voice, sound, image, video, graphics, structured data). They are undergoing a rapid evolution and will create a paradigm shift on how people communicate and exchange and use information. If technology allows, a new level of multimedia communication services will emerge that is richer, of higher quality, ubiquitous, context and access aware while being affordable. This new level of multimedia communication services improves the life of the individual, but it will also improve the efficiency of the European business. Communication will be as good as being there.

5.4.2 Objectives

The objectives are to develop the technologies required to deploy improved and extended Multimedia communication services across Europe. Extensive R&D must be carried out to ensure that:

- The media and service quality is sufficient regardless of context
- The requirements from different communication services, situations or contexts on parameters such as network delay and jitter are understood. Solutions to fulfil these requirements and to predict the quality as experienced by the end-user
- The services are efficient regarding, e.g., network resources, spectrum, battery, regardless of device, context and access network
- The services will work across networks and devices
- The cost involved in launching and using the services is reasonable

5.4.3 Research Priorities

The following research items can be identified as examples:

- **Media formats, media compression**: A continuous development is ongoing in the media compression area for different media (e.g., audio, graphics, still image, speech, video). The required bit-rate is ever decreasing (thereby increasing efficiency) while the quality increases. New dimensions are added (e.g., 3D, multi-channel). A specific challenge is to develop media formats that can be used regardless of access, input and output devices and terminal types while maintaining compression efficiency. These codecs are known as scalable codecs. Such formats would enable the use of one media

format for all usages thus removing the need for trans-coding, media conversion and encoding several versions of the same content. The alignment of media formats would overcome the current fragmented situation that hinders fast service take-up over access and device boundaries. It would also reduce the costs involved thereby making services affordable.

- **Media transport**: Defining the appropriate methods and protocols for media transport. This area may include specific aspects like management of congestion situations. Important challenges are group communications, as well as, broadcast over heterogeneous networks and terminals.
- **Media adaptation**: Technology for media adaptation based on terminal capabilities, network and access resources, user preferences, as well as, context should be studied. Media adaptation means both changes within a media (reducing the bit-rate required for a media by, e.g., transcoding) as well as changing media (e.g., video to slide-show, text-to-speech). Basic technology and algorithms, as well as, network architecture should be studied, and should be aligned with the research on new media formats and compression.
- **Terminal front end input**: The development of technology that predicts and enhances the media quality in person-to-person (and group) communication services. Includes ambience suppression (e.g., noise suppression), finding the direction and location of the source and predicting quality of experience based on, e.g., network measurements.
- **Terminal front-end output**: The development of technology that presents the media to the user in the best way includes advanced displays, methods to present 3D sound, graphics, images and video, multi-channel rendering.

5.5 Service Execution Environment

5.5.1 Rationale and Objectives

In terms of innovation for mobile services and service architecture, the objective is to bring it to reality and to take advantage of the progress achieved in parallel in other domains such as radio and networks infrastructure, in order to contribute to a wide adoption of the mobile services, as well as, the fixed ones seamlessly.

To achieve these goals, all the players in the mobile communications field have to make progress in the area of service architecture. The objective is to remove the hurdles which prevent the adoption of mobile services by providing the missing links in addition to the existing standards and components.

5.5.2 Research Priorities in Service Architecture

- Providing a homogeneous and open service execution platform on the terminal side in order to facilitate the deployment, the adaptation, the management and the execution of any mobile services. Today the heterogeneity of software environment such as the operating system on mobile terminals makes this concern very tangible. For instance, a widely adopted open source initiative could bring a very significant improvement to solve the current fragmented situation.
- Overcoming the heterogeneity of mobile and fixed infrastructures at the service level, in order to smoothly educate the market with service architectures that simplify the way to communicate seamlessly in heterogeneous environments. Such a concern is important to manage, in order to move from legacy architectures to new generation ones.
- Providing enabling components that support more intelligent mobile services (e.g., scalable support for semantic publishing and discovery, reasoning, knowledge inferring, learning, profiling, contextual information gathering).
- Proposing a standardised architecture in order to support and facilitate the adoption of a new generation of services by considering the evolution of usage of mobile equipment. For instance, in addition to their standard use, mobile handsets can be used as mobile gateways between sensors, players or others gateways.
- Reconfigurability of IMS nodes, from hardware up to application layers, in order to take into account the different services requirements.

6 Ubiquitous Connectivity

6.1 Vision and Rationale

There are several networking challenges presented in the vision chapter. A key consequence is that of scale. In pervasive wireless applications and services, the users will use a truly substantial number of wireless terminals and devices and networks. People and all their "things" communicate: there will be a transformation from one transmitter per thousands of persons as in the broadcast case, and one transmitter per person in the mobile telephony, to hundreds of tiny wireless devices per person in the ubiquitous networking world. The networking technology will need to undergo a transformation, from a highly visible, “hi-tech technology” to a “disappearing technology” that everyone can afford, use and deploy. A truly pervasive technology is (almost) taken for granted to work and be extremely reliable and dependable. Electric power is a good example of such a technology. An invisible technology needs to be:

- Auto-everything (almost no conscious user interaction to configure, easy install and operate network elements and terminals)
- Reliable, secure, **trusted** and **simple** to use
- Simple to add new services and to select service providers
- Extremely low cost (the future user will spend proportionately a similar amount of money than today on ten to a hundred times as many wireless devices and their communications)

The networking world will become a world consisting of **wide-area networking** including moving networks and a **local networking** ones including wireless sensor networks, RFIDs, personal area, local area and home networks.

- **Wide-Area domain:** It is one of today’s public systems providing fixed broadband networks and wide-area mobile cellular. “Natural monopoly” economics rule this domain and public operation, with few competing market actors is the natural evolution. “Any-time-any-where” communication is what a user expects. Hence the demands on reliability have to be very high. Interworking with other network infrastructure will provide full connectivity between legacy and new types of networks, e.g., home networks, office networks, body networks, campus networks, vehicle networks, moving networks, and production networks. A common service support over all these networks makes the services ubiquitous anywhere over any access with the potential to use a multitude of different end-user devices.
- **Local domain:** There are different types of networking closer to the user and includes local wireless access in homes, offices, shopping malls, where people live and work. In

this world there will be a large number of competing and complementing technologies that will cater for reliable access and larger capacity at low cost. This world will also be characterized by a higher degree of ad hoc and opportunistic communications where non-infrastructure networks form and reform dynamically at different time-scales primarily dependent on mobility patterns and other contextual factors. Here new wireless terminals and infrastructure components (similar to electric appliances) are no-maintenance or disposable and self-configuring, local access networks that can be deployed in minutes without requiring highly skilled and trained personnel. This will radically lower the entry thresholds for new actors in the infrastructure field which creates new business opportunities and competition. Facility, shop and restaurant owners and even private persons will provide both wireless access to global services, as well as, value-added localised services. The infrastructure components will form an integrated part of the wireless grid accessible to the public. The large diversity and efficient competition between providers of network and service elements or combinations thereof will provide seamless service according to user preferences.

The architecture of such systems will be mainly characterized by following features:

- **More intelligence in the end-points – not in the transport infrastructure:** Moore's law is applicable to electronic devices - not for infrastructure since infrastructure costs are dominated by wiring, installation, maintenance etc. New user equipment and servers appear on the market in a matter of months, whereas large-scale infrastructure deployment takes years. Therefore appropriate technologies are needed that enable flexibility in reconfiguration, adaptation and self-healing through for example intelligence at the end-points (terminals, access points, PANs, devices, and network elements such as servers and gateways). IP-based (or similar) transport network, independent of access (fixed or mobile) – the end-to-end principle applies to all services beyond basic connectivity, and are provided at the edges of the network, not by the transport network itself. In order to provide this flexibility the transport network has to provide sufficient capabilities such as high capacity and throughput to be prepared for potential future developments at the edge systems to avoid bottlenecks in the less intelligent large-scale infrastructure. However this should not preclude the introduction of advanced mechanisms in the transport network (radio access, core) that would intelligently optimise the available resources with respect to the capacity demand. To this respect, smart priorisation algorithms, policing capacity and alternate routing / multihoming, to name a few, should participate in the analysis of traffic nature and properties, adapting dynamically to the current conditions in real time for the optimum network resources utilisation at a particular moment.

- **From "Single system for all needs" to navigating in the "Wireless mayhem":** No single wireless access solution or radio technology is capable of providing cost-effective wireless access in all scenarios and for all user needs. Large investments are already made in existing networks and technologies which already provide cost-efficient solutions for certain applications, e.g., wide-area voice and medium data rate wireless local area networks (WLANs). Instead, future wireless access will be provided by a system of heterogeneous access networks. New access technologies will appear (e.g., Beyond 3G, high data rate WLAN, gigabit-per-second short range systems, BWA) and many will be successful in niche scenarios, thus complementing existing technologies rather than replacing them. More advanced radio access networks (RANs) (e.g., for high speed mobility and quality of service (QoS)) will need to coexist with simple local access solutions (e.g., best-effort nomadic connectivity), and modern infrastructure will coexist with the old. Multi-service capability and mobility over multi-access networks (fixed and the mobile networks) enables true connectivity for all and everywhere.
- **Multimode access for cooperation and competition:** Multimode terminals can adapt to both new services and new wireless access technologies in a much faster and flexible way, than the infrastructure itself. Significant cost gains are derived from multimode terminals and efficient use and reuse of access resources. The fact that full coverage is not necessary for all access options is probably a key factor for new radio access technologies. Infrastructure can be incrementally and cost-efficiently deployed, where needed. Effective access competition will provide additional benefits for the users.
- **Networks that automatically "compose" and manage themselves:** The heterogeneity between the network administrators will increase, ranging from the typical non-technical personnel who expects the systems to work flawlessly and will spend only minimal, if any, time on managing the systems to the experts managing the large networks of today. Furthermore the dynamics within and between these systems will increase, and the large providers want to spend less money on management. This implies that the management systems must be more self-managing, be able to cope with most situations autonomously, and when interaction with an administrative person is required, present the problem as abstractly as possible and provide easily understandable tools to remedy the situation. These autonomous functions have to work also on the network control layer, enabling the negotiation of agreements between networks, as well as, their efficient verification and enforcement.

The following table explains how the Research Priorities (RP), introduced in the following sub-sections, contribute to the enhancements of each axis of the SET concept.

Research Areas	SET	Contribution to SET concept
Radio Access	S	Introduction of self-configurable access schemes and reconfigurable transceivers.
	E	Aggressive introduction of novel space-time-, frequency- and power-signal processing, and transceiver algorithms with minimal extra overhead to the broadband access systems. Power efficiency for the short range connections. New deployment strategies such as multihop, mesh and cooperative networking. All these are equally applicable to both links between Access Points (Backhaul system) as well as User Access (commonly know as last mile).
	T	Always accessible secure wireless connection to the networks without user knowledge of available access schemes.
Networks	S	Automation of Management by using innovative methods for self-configuration, self-management, self-provisioning, and self-healing. Hide the complexity.
	E	Efficient application development framework. Intelligent resource discovery and Management. Always Best Connected. Efficient transport.
	T	Security, Trust, Privacy, network resistance should be well integrated in the network.
Platforms and implementation	S	New computing platforms for mobile devices must be simple to use both by users and by developers. The functionalities provided by the platform software (OS and middleware) must reduce the effort and time needed to add new advanced services, and to have them cooperating. Retargeting to multiple product domains and product variants should become straightforward.
	E	An efficient platform is a prerequisite to provide efficient services to the users. The platform software layers need to efficiently scale and adapt to the emerging multi-processor and network-on-chip computing platforms to take benefit of the increased efficiency they can provide. Advanced middleware services should provide innovative ways to efficiently integrate different communication and coordination models.
	T	New computing platforms must offer a large set of basic

		functionalities to easily implement safe, secure, and reliable services for the users
Opportunistic communication	S	New adaptive radio system must be able to automatically adjust the way they operate to obtain the best performance in every possible scenario
	E	By increasing spectrum utilization, opportunistic communication has the opportunity to increase communication efficiency solving today's problems and increasing the scalability of the system.
	T	Opportunistic communication should provide reliable communication in situations where today technology cannot be reliable, thus increasing the overall dependability of the system.

Table 6-1 SET and Ubiquitous Connectivity

6.2 Ubiquitous Networks

6.2.1 Rationale

Flexible growth from small-scale, up to Europe-wide and global systems and services needs to be supported, enabling a wide variety of both wide-area and local solutions for all the various application areas offering, including unicast and multicast services. One key element will be wireless and fixed access with optical transmission integration. A heterogeneous networking environment as outlined in the previous section calls for means to hide the complexity from the end-user as well as applications by providing intelligent and adaptable connectivity services, thus providing an efficient application development framework. In this section we present possible impacts and technical challenges the vision presented in the previous section will have on networks and network architectures.

Fixed-mobile convergence (FMC) of both services and networks play a major role in realisation of our vision, allowing users to be always reachable and having access to their normal personal service environment. A first step towards this is to enable nomadism in the fixed access network meaning the ability to reconnect to the network at new locations and being able to access the home service environment. The next step is to be able to do the same across different mobile access networks, for example between access networks controlled by different operators and administrators. The last step in the evolution towards a true always best-connected network is the seamless and efficient interaction between the fixed and the mobile/wireless networks. The interworking and convergence between the fixed broadband networks and mobile networks will

be a key factor in order to achieve the eMobility vision. The future infrastructure will support multi-service capability and mobility over multi-access networks that enable true broadband for all and everywhere.

The complexity of network management will also increase between the providers of network connectivity. This is addressed through provision of substantial automation for achieving both network composition and cost efficient network operations and maintenance. The autonomous functions should also operate on the network control layer, facilitating the negotiation of agreements between networks as well as their efficient verification and enforcement. This will include policy-based networking within a given business framework to enable maximum and stable use of the networking resources.

The emerging communication systems are oriented towards the interconnection of heterogeneous networks able to provide various types of services, including those with high transmission rates and with quality of service guarantees. The integration of optical and wireless technologies allows an efficient solution to provide multimedia services to the end user in high traffic density areas, merging flexibility and mobility characteristics of the wireless networks with the high capacity of the fibre.

Applications will have to be supported by intelligent connectivity service taking care of context information and relying on user and application preferences; for instance by increasing the semantic understanding of media flows in the network. The composed connectivity networks must provide predictable and dependable connectivity service to applications with the acceptable robustness in order to be trusted by users and service providers. At the same time, the connectivity service must be secure enough to identify, isolate and autonomously react to any malicious behaviour by, e.g., applications.

IP as a data delivery technology was invented in the time where networks had static configurations and mobility was non-existent. Generally speaking TCP/IP Internet solutions assume a fairly predictable and simple notion of the end-to-end communications. This implies that operational assumption for the TCP/IP depends on the need for availability of at least one permanently functional path between a source and a destination with relatively small end-to-end delay and packet losses for the given path. This major assumption does not always hold true in a dynamically varying mobile/wireless environment. The emergence of sensor networks, RFIDs, ad-hoc networks, and large mobile networks with high and varying cases of mobility, various degrees of intermittency, heterogeneity in many different aspects of networking and diversity of services available questions the very essence that the Internet paradigm was built on. That is, the

assumption of the end-to-end communication and properties of the underlying communication media as mentioned above. The Delay Tolerant Network Architecture (DTN) in IETF, recognises this shortcoming and provides recommendation for a very specific research in the Interplanetary Internet but at the same time introduces interesting notions and solutions for Internet evolution in areas of architecture advancements concerning services, topology, routing, security, reliability and state management. This research offers useful insight in methods of adaptations and enhancements of Internet communications in the emerging communications paradigms. The case being investigated in the Delay Tolerant Network Architectures bases the argument on the specific examples of networks where the end-to-end communication delay is highly variable and large with different expectations on the transit properties and delivery constrains of the traffic. This can be interrelated with some of the abovementioned recent types of emerging communication environments in the Internet and considered as an important challenge in *evolving* Internet communications paradigms and associated solutions.

With advances and lessons learnt in the past 40 years of network architectural designs, combined with in depth understanding of requirements of current and future wireless systems, there should be a parallel and clean slate (*revolutionary)* approach to the future generation of internet in the Post-IP era internet. This is differentiated from the evolutionary and patchwork enhancements to current Internet emphasising on the fact that the future trend on devices research is shifting from current practice of e.g., content or a software application process towards networking of mobile/device objects. The Post-IP Internet research includes challenges that relate to the data delivery paradigm or IP itself where routing of datagrams is inefficiently based on addresses of a virtually static and common global infrastructure. The notion of an IP address itself is another reason for inefficiency of IP for mobile/wireless communications and supports justifications for new and revolutionary approach. There is a need for research on a new set of protocols which are more wireless friendly and also provide a smooth migration from current IP to protocols and architectures where mobility, security and mechanisms for quality of service support are the fundamental basis in the design of protocols and architectures in next generation internet in the Post-IP era.

6.2.2 Objectives

The major objectives of the research are therefore to:

- Fixed Mobile Convergence – nomadism and mobility with session continuity with alignment of business models, roaming protocols, user & service management and architecture between fixed and mobile networks.

- Enable the future infrastructure supporting multi-service capability and mobility over multi-access networks (fixed and mobile networks) with heterogeneous devices where privacy, security and safety are prerequisites but need to be easily managed.
- Enable interworking and convergence between the fixed broadband networks and mobile networks to reduce cost and make services available everywhere including full acknowledgement of optical transmission.
- Unbundling: Network architectures that allow for collaborative business models in which complementary providers join forces, as well as for unbundling of the access network to competing service providers in order to achieve the most attractive service offer for the end-user.
- Propose new Post-IP networking and architectures coping with the new and emerging wireless networking requirements in next generation internet.
- New protocol frameworks and collapse of current protocol stack and layering into minimum required protocols in face of widespread availability of fibre optics networks.
- Complement research effort on networking of devices with networking of information, e.g. towards semantic technologies, data fusion etc., to support ubiquitous availability of content and information for all application scenarios (e.g. user-centric, M2M-centric).
- Define a network architecture that supports high-bandwidth real-time services over multiple access technologies
- Understand the evolution towards context-awareness and support of cognitive networks and media-aware networking thus providing the intelligent connectivity services required for efficient application development
- Enable an always-on experience: Information can be accessed anytime, anywhere as if it were stored locally (e.g., music database on mobile players) even in the case of intermittent or fluctuating connectivity.
- Create support for network and system management that are highly self-managing to lower the level of required skills and effort to manage such networks. These management systems will also be highly distributed to cope with the size of and with the high level of dynamics in and between the networks.
- Enable harmonisation of actuations amongst sensors, monitoring and control applications working under critical requirements (e.g., security, availability, reliability, speed of action).
- Develop support of automatic context-aware discovery, selection and composition of devices, networks, resources and services as well as personalised service selection and decision making.

6.2.3 Research Priorities

Today's trend is that large, feature-rich systems tend to become more complex to specify, build and operate. Hence further research is needed on:

- Design of post-IP technologies, specifically novel data delivery mechanisms matching the dynamics of large scale mobile networks and particularly for adhoc and infrastructure-less networks and network constellations, richer notions of networked objects including new means for naming, addressing and identification. Layered vs. non-layered stack design, statically or dynamically configured networking stacks should also be included. The solution should operate efficiently over both fixed as well as mobile networks.
- New protocols optimised for packet-only in a public access environment. Especially capacity and latency-effective alternatives to IP and TCP.
- Full delay tolerant networking.
- Radio over fibre influence on new collapsed and minimum protocol framework.
- Scalability and optimization of network and service control technology which can deal with all sizes of network from small, ad hoc networks up to large-scale corporate and public wide-area networks employing a common networking concept. Concepts for intelligent distribution of services across multiple access technologies.
- Fixed and mobile convergence with focus on service, device convergence, and network convergence where both the fixed and the mobile network use the same multi-service layered architecture that improves efficiency and flexibility.
- Auto-configuration and self-management mechanisms which are able to autonomously deal with dynamic configuration changes (for example, small footprint networking technology), including multi-mode multi-band radio, radio resource management, application-based charging, instant network composition and decomposition, automatic roaming agreements, interworking between new and legacy management systems, multi-hop radio networks, software configurable radio interfaces, multi-link phones (terminal, router and repeater functions), flexible quality of service and in particular from user's point of view quality of experience.
- Ability to cope with a wide range of radio technology as well as application middleware to support applications with more intelligent communications services.
- Development of new network topologies and routing structures to cope with a composition of multitude of networks.
- Alternative deployment strategies and technologies for capillary networks.
- Design of network topologies. Mesh architecture should be validated in an integrated wired/wireless network. Mesh networks with wireless routers potentially used to form a wireless backbone, providing wireless transport services to data travelling from users to

either other users or access points with high bandwidth wired Internet connection. The utilization of wireless mesh networks in the last mile as well as backhaul links offer the advantages of flexibility, rapid deployment, high scalability, lower maintenance and lower upgrade costs.

- Multi-layered (ISO layers as well as overlaid/underlaid cell layers) mobility support, which enables ad hoc cluster mobility, as well as, user-mobility across networks.
- Delivery of information and media flows to users, adapted to their current access situation, location-dependent interests and preferences.
- Unifying solutions for personal networking (PN), interaction with body area networks (BAN), new types of home networks, vehicle networks, wireless sensor networks (WSN), RFID, deployment and operation of emergency networks, and other network types.
- Security and robustness to sustain malicious attacks with inherent self-healing configuration mechanisms, QoS and policy-based networking (e.g., policy-enabled service on demand), firewalls, authentication and trust management technologies.
- Secure and trusted application environments including damage prevention and control techniques for connectivity (Network security, information and trusted content security).
- True multimedia support: Basic technologies for content distribution over heterogeneous networks and media conversion techniques for multi-modal presentation of content to users.
- Transport network evolution for reliable, cost efficient, easy-to-deploy-and-integrate solutions taking optical and BWA transmission fully into account.
- Solutions enabling efficient OPEX and CAPEX for fixed very high bandwidth multi access networks with scalability for number of users and bandwidth including a variety of first mile technologies such as fibre, fast DSL and BWA.
- Efficient solutions for access networks with fibre, fast DSL or BWA drop technologies enabling very high bandwidths.
- Investigations of Traffic Engineering solutions in both the wired and wireless MANs to balance the traffic. The utilization of different traffic engineering schemes to manage specific issues of optical/wireless networks, such as physical impairments, node architecture, routing and wavelength assignment.
- Interaction of the routing protocol with physical, MAC, and transport layer to optimise the traffic engineering schemes.

6.3 Radio Access

6.3.1 Rationale

Future Radio Access will be using many different technologies each tailored for its particular niche (e.g. WSN, PAN, LAN, Home Network, wireless sensors, proximity perception, accurate positioning Moving Networks, Wide Area Networks). In some cases, singular access points will be joined together by the heterogeneous networking techniques outlined in previous section, in other cases, larger entities, Radio Area Networks, will be formed that allow a more tight integration between access points and access technologies to provide a better Quality-of-services, in particular in wide-area mobile systems.

Extensive and high quality ubiquitous wireless access cannot be managed with the currently established infrastructure or with emerging ad hoc radio network technologies as the traditional radio access schemes will not scale to large collections of nodes and is destined to be plagued with unmanageable interference, and network congestion. To develop such scalable and dynamically pervasive wireless access, there is a need for fundamentally new methods to address spectrum sharing cooperative and adaptive link management, opportunistic access, information routing, and quality of service management.

The future wireless access schemes should be developed to facilitate flexibility for the allocation of throughput values per user, high aggregate average throughput per area, low latency and high cell edge capacity, as well as high speed access with somewhat modest power consumption requirements and different access range as well as relatively short range techniques having the power saving (lower power wake-up radios etc.) as some of the key driver.

In recent years the majority of research effort aimed at creating efficient, ubiquitous, wireless access has concentrated on improvements to the last link in the chain from network to user (user link) – often referred to as the “last mile”. However, an inevitable consequence of increasing user data rate is the shrinking of the range of the “last mile” link, such that it may be more correctly described in the future as “last hundred metres”. This leads to a need for an increase in numbers of “base stations” or “access points” of perhaps as much as two to three orders of magnitude. This brings a corresponding pressure to push down the size and cost of the hardware – assisted by the economies of scale of the increased equipment volumes. Once the radio hardware size and cost is reduced, the cost of providing the next link in the chain between base station and core network will become dominant. DSL technologies have promise where copper already exists, but even with the tumbling costs of DSL in Europe, the capital cost of a WLAN access point today perhaps represents only 3-6 months running cost of a DSL line. Indeed if an uncontended DSL

line is required, then the cost of the link will exceed that of the access point hardware in a matter of days.

If it is necessary to install a base station or access point somewhere where no copper loop exists, then the deployment cost rises substantially if trenches need to be dug to run new cables or fibre. Increased availability of fibre infrastructure may bring high bandwidths within hundreds of metres of users, but there is a need for a solution to provide an inexpensive way of bridging the gap between the end of the fibre and the radio access point.

The cost of point-to-point microwave systems is falling as volumes increase, but they still suffer from the need for rigid support and substantial effort to align antennas and commission each link. In addition, in order to become future-proof, microwave systems need to be able to increase capacity by employing higher spectrum efficiency techniques. This may include use of adaptive modulation and coding to reduce the planning margins required to limit link outage. Moreover microwave systems need to evolve from current “line-of-sight only” applications to non-line-of-sight deployment to extend their applicability and to make the network design and implementation process easier.

6.3.2 Objectives

In the development of future RANs, and backhaul systems the **efficiency** will become even more important issue than ever. Operators publicly providing RAN solutions are in a new business model where they need to compete with other operators and access technologies for various applications. New solutions for access technologies (both user and backhaul links) and signal processing methods are needed which result in efficient use of spectrum and network resources, and higher throughputs, through appropriate cooperation and adaptation techniques. Simple and low-cost deployment of access infrastructure is of paramount importance to the overall economy of access provisioning. The target is not necessarily higher bit rates as in the past but *high and uniform* capacity in most of cell coverage such as 85% of cell area. Autonomous self organisation is needed to continuously operate at the optimum point under dynamically varying conditions, as well as capabilities to easily incorporate (as yet unconceived) future services and requirements.

Radio access network and backhaul system research are part of the overall system design. It needs to be emphasised that radio interfaces for the future should be designed jointly with the overall systems. However, achievement of major advances in, e.g., RAN capacity, power efficiency, distributed network control, new network topologies requires also independent and highly focused research at different layers. This results in an integrated and iterative design

process, where the major difference with the past is that the overall system design is much more emphasised.

In-band mesh networking (i.e. backhaul sharing spectrum with user access) is increasingly being considered as a solution to linking WLAN access points, but suffers from capacity limitations as traffic levels grow. Out-of-band mesh topology instead promises to cope with the capacity and performance requirements if adequately designed.

The ideal backhaul system would:

- Be built-in to each base station or access point
- Use a single transmission network to handle legacy (i.e. 2G, 2.5G and 3G) and future mobile network and access points traffic
- Have low capital and operating costs compared to current solutions
- Have a range of ~1km, ideally not requiring full line-of-sight and several km when LOS available
- Have sufficient capacity to support the traffic of a few tens of base stations
- Support at least 2 links to other nodes to allow development of a redundant mesh for reliability
- Be fully self configuring with no manual setup
- Be modular to adapt to changes in network topology for example due to adding new radio sites
- Implement QoS mechanism to prioritize traffic depending on instantaneous available capacity (possibly depending on radio propagation conditions)
- Add minimal additional delay to that already inherent in the radio access network
- Support accurate transfer of time and frequency standards to the base station
- Operate in spectrum which is available throughout Europe and not currently in short supply
- Easily interface to existing wired or fibre fixed infrastructure
- Employ open standards to enable multi-vendor supply

One major paradigm shift driving the future RANs and backhaul systems development is related to more liberal spectrum allocation policies, leading to **simplicity** in regulation and **efficiency** in spectrum usage. Opportunistic communication technologies based on the concept of cognitive radio must be extensively researched and developed for this purpose. This will be treated in more detail in Section 6.4. The flexibility, adaptivity and multi-functionality requirements leading to multi-radio and cognitive radio concepts require new transceiver architectures which will be discussed in Section 6.5.

6.3.3 Research Priorities

The target is to develop future integrated systems in a unified manner. The commonalities of different access networks are utilised to support developing a flexible radio for the future whilst maximising the unique capabilities of different types of networks by somewhat independent system optimisation. The identified major research areas pertain to user link (radio access) as well as backhaul links between access points and concerned with deployment concepts, radio interface technologies, reconfigurability, spectrum and coexistence, trials and prototypes, as well as, regulation and standards.

The Radio access research topics include:

- Joint optimization of coverage, capacity and quality techniques through co-operation and adaptation techniques involving different layers in protocol stack assisted by information from physical layer and radio environment.
- Efficient mechanisms for joint exploitation and operation of available diversities in time/space/frequency/code/power domains.
- Development of radio access schemes with high peak aggregate spectral efficiency for noise-limited environments and high area average aggregate spectral efficiency values with high cell edge spectral efficiency for interference-limited environments.
- Radio access schemes with high flexibility and adaptability of data rate allocation to users.
- Investigation of alternative, low cost deployment concepts, new network topologies and system architectures beyond the classical cellular approach, such as relay-/multihop-based concepts, meshed networks, distributed antennas and radio over fibre for signal distribution.
- Intelligent resource (frequency, battery, power, hardware, software) discovery and management techniques.
- Evaluation of Network Information theoretical limits of cooperative and self-organising networks and research into advance coding design and signal processing schemes to achieve these limits.
- Investigation of the impact of new frequency bands for future systems on the radio propagation and specification of appropriate output power levels to ensure compliance with relevant guidelines and regulations related to human exposure to radio frequency electromagnetic fields.
- Study new methods to reduce or manage interference especially in short range cellular systems with high frequency reuse to maximize coverage, throughput and spectral efficiency.

- Development of methods for supporting efficient multicast transmissions in cellular systems with significantly different fading channel conditions for the links to and possibly different levels of meaningfulness of the transmitted information for various recipients.
- Development of the self-configurable user terminal by the Software Radio technology to assure mobility to the final user and an efficient interoperability among different networks.
- Development of software defined radio technologies for increasing multi-standard capabilities of base stations and reduce cost by diminishing diversity of hardware platforms.
- Close liaison and working through contribution to the international standardisation activities to achieve global impact.

The Backhaul link research topics include:

- Low cost GHz - THz generation and reception
- Microwave adaptive arrays – low cost production of electrically steerable antennas, ideally with no moving parts
- Algorithms for self-configuration and routing in fixed mesh networks
- Techniques for transfer of time and frequency standards
- Techniques to maximise spectrum efficiency in NLOS transmission at lower microwave frequencies

6.4 Opportunistic Communications

6.4.1 Rationale

The demand for wireless communications will continue to increase at an accelerated pace, which with the current paradigm of spectrum allocation and licensing will undoubtedly lead to a spectrum crisis, even with the development of highly spectral-efficient transmission techniques. Nevertheless, considerable spectrum might be available if both the dimensions of space and time were considered, and hence the problem is more a problem of inefficient spectrum access to under-used parts of the spectrum rather than spectrum shortage.

While such an approach represents a major deviation from the current paradigm of spectrum allocation, the debate on alternative and more efficient spectrum management policies has started in the standardisation bodies and national regulation agencies, but to support the eventual step of going towards a more liberal approach of spectrum management, the decision-makers need proof of evidence of the viability of technologies that would enable the alternative approaches.

Providing novel mechanisms for enhanced and more efficient spectrum usage would support the i2010 initiative of the European Commission towards the Information Society. Opportunistic communications would likely facilitate the emergence of new business models. For instance, they might support the implementation of much heralded secondary spectrum market, by using or leasing some licensee frequency bands for a limited time period and under some specific constraints on interference level.

6.4.2 Objectives

The development of frequency-agile terminals that can sense holes in the spectrum and adapt their transmission characteristics to use these holes may provide one tool to address and take advantage of the spectrum under-utilization. Although, some current adaptive radio systems already exhibit the feature of automatically adjusting their parameters for a given standard, the development of truly agile terminals requires to go much further, since it is not possible for the designers to foresee all the possible environment scenarios and then provide deterministic schemes for selection and reconfiguration.

Opportunistic communication challenges fit in the general framework of the Cognitive Radio research, focusing specifically on techniques exploring mainly the frequency dimension to find and use the best spectrum and space opportunities in a fair manner. Research needs to be conducted on concepts, mechanisms and architectures for cognitive radio terminals and networks. Socio-economical advantages of opportunistic spectrum usage in both time and space need also to be demonstrated.

6.4.3 Research Priorities

The main areas of opportunistic communications requiring research advances include:

- Sensing techniques to acquire relevant information from the radio environment and define the feasible operating region
- Decision making processes to allow intelligent choice of spectrum access, based on spectrum access policies available or unused spectrum
- Optimisation procedures to define the best waveform when applicable given the environment
- Identification and dissemination of space dimension opportunities in opportunistic radio networks and collaboration strategies to efficiently make use of them on a network level
- Adaptable and flexible broadband RF frontends for variable carrier bandwidth
- Adaptable baseband architectures that may efficiently adapt to the radio environment
- Scalable and reconfigurable techniques to support all digital RF flexible transceiver architectures

- System-level studies to evaluate the effectiveness of the proposed techniques in terms of system parameters (e.g., capacity, QoS)
- Prototyping and field trials

6.5 Platforms and Implementation

6.5.1 Rationale

Pervasiveness of future wireless applications and services will integrate the computation and wireless communication capabilities in a great variety of mobile devices both on terminal and network sides. To achieve wide acceptance, the devices and their designs should exhibit new degrees of scalability, flexibility, security, energy-aware performance, cost efficiency and design productivity applicable for a wide range of products that provide users with intelligent context-aware services via heterogeneous networks.

Digital convergence will combine technologies in products in new ways that force tighter synchronisation of roadmaps between different technology domains in order to ensure the availability of all necessary technologies in time. Different parts need to be specified and optimised jointly to identify common features crossing the borders of the domains. This holds for antennas, radio frequency front-ends, baseband signal processing, and displays as well as for computing architectures, middleware and application software and user interfaces. Standard interfaces and open communication and computing platforms are needed to facilitate this collaboration.

Future mobile devices will continue to drive the development of many semiconductor product sectors, especially the potential migration to higher frequencies asks for pushing RF CMOS circuits beyond the current limits.

6.5.2 Objectives

Merging several simultaneous network access schemes, high data rate communications and multiple concurrent diversified applications will severely challenge the scalability of current platform approaches. Future communication and computing platforms need to be based on new modular architectures (e.g., network-on-chip) and design methodology paradigms (e.g., model-based and platform-based design) facilitating reuse over a wide range of products to obtain shorter time-to-market, lower costs, increased reliability and to amortise investments.

The multiplicity and diversity of media access control processing, protocols, middleware, applications and smart user interfaces cumulate to huge complexity in many dimensions including

functionality, architecture and internal communication. Computing platforms of mobile devices will require heterogeneous multiprocessing architectures that need to interact continuously with their environment and to transfer and manage large amounts of data. The platform should be capable of accommodating very diverse types of applications, provide them with a secure execution environment and support software download. The ultimate objective is therefore a mobile device computing platform that would allow retargeting to different product domains and product variants. In addition, the envisaged platforms and architectures require major leaps in the design methodologies and tools for specification, design and implementation like model-based design, performance modelling and evaluation and platform-based design.

The basic functionalities provided by the platform software layers (e.g., RTOS, device, connectivity and network management, user interface and application interface) will remain, but the structures need to scale and adapt according to the emerging multi-processor and network-on-chip computing platforms. The key issue to be studied is how this can be done efficiently considering the stringent resource constraints of mobile devices. Offering of open standard-type interfaces, e.g., in the form of APIs, is essential in order to achieve an open execution environment for envisaged intelligent context-aware services to be offered via heterogeneous networks.

A multiple access environment in heterogeneous networks will result in more complex systems with respect to signal processing. In addition, requirements on environmental issues and the impact of electromagnetic radiation on the human body have to be considered. Constraints on the power consumption and the cost of mobile devices require investigations of the impact of sub-micron integration on the circuit and system level. The adaptivity and multi-functionality requirements leading to multi-radio and cognitive radio concepts require new RF front-end architectures. Joint optimisation of the antenna, RF front-end and digital baseband modem will be needed. A flexible-reconfigurable platform optimised based on the maximum amount of commonalities would allow retargeting to different products and give possibilities to achieve low costs through economies of scale.

6.5.3 Research priorities

The main areas of **computing platforms** requiring research advances include:

- Platform and architecture concepts that take into account the needs of users, businesses, services, connectivity, and different associated technology domains.
- Network-on-chip and multi-processor system-on-chip architectures, packet-based intra-communications, interfaces and resources.
- Interaction with multiple parallel radio interfaces, co-existence of multiple protocols.

- Design methodology and tools for model-based design, platform-based design, performance modelling and evaluation, power modelling and evaluation, functional validation and verification.

The main areas of **platform software** requiring research advances include:

- Extensible middleware architectures: dynamic architectures, self-organisation algorithms and strategies, and negotiation techniques.
- Middleware services: automatic and scalable service discovery, adaptive resource management, authentication with dynamic configuration, standard-based light-weight middleware solutions with support for interoperability, heterogeneous devices, software solutions and applications, and self-aware middleware services.
- Performance monitoring and analysis, security modelling and testing, survivability methodologies and mechanisms, reliability and availability evaluation.
- Cost-effective development methods, middleware frameworks and test-automation.

The main areas of **antennas, RF front-ends and baseband processing** requiring research advances include:

- Innovative transceiver architectures and jointly optimized RF and baseband hardware designs, matching the nano-electronics roadmaps and exhibiting new degrees of scalability, flexibility, security, energy-aware performance, cost efficiency and design productivity
- New architectures of broadband and adaptable RF front-ends matching with the microelectronics roadmaps and including advanced technologies and components such as RF MEMS and NEMS (Nano Electro Mechanical Systems)
- Development of simple and cost-effective base station architectures based on the integration of photonic and electronic devices. The base station and the link design should take into account some critical design parameters such as, for example, radio and optical link losses, optical and radio impairments and optical amplifier gain.
- Joint optimisation of the front-end and the digital baseband modem, including analogue and RF behavioural modelling as well as digital compensation of their impairments
- Efficient analogue-to-digital co-simulation
- New design methodology for hybrid devices including micromechanical and electrical components
- Synthesis and verification of reconfigurable architectures
- Synthesis and verification of Network on Chip (NoC) architectures
- System level (System on Chip, Network on Chip) methodology and tools
- Integration of embedded non volatile memories (e.g., MRAM, PCRAM, PMC) on chips

- Design of fault-tolerant chip architectures
- Design of smart memories including data management at the hardware level

The main areas of **power consumption challenges** requiring research advances include:

- Long-lasting and lightweight power supplies for mobile devices, energy scavenging techniques and piezo materials.
- Techniques for low power communication and computing architectures.
- Cross layer optimisation to exploit flexibility in order to save power.
- Improved power dissipation techniques applied to telecom equipment to control difficult climatic conditions.
- Reduction of power consumption by using low power technologies and by developing interaction between hardware and embedded software (e.g., monitoring of voltages, clock frequencies and threshold voltages).

7 Business Infrastructures

7.1 Vision

Future systems have to support a changing and flexible mobile ecosystem. Therefore it is predictable that multiple viable business models will coexist with the emerging new actors leading to a new supporting architecture.

Indeed, the traditional stakeholder model (e.g., content provider, service provider, network operator, equipment or device manufacturer, end-user) and the stakeholders' relationships can have significant evolutions. New stakeholders are now appearing, mainly providing value-added services for enabling efficiency and system interoperability, network monitoring and management, customer-care support and device management.

Among the new stakeholders, one can identify virtual network operators, sensor network and RFID manufacturers, sensor network connectivity operators, mobile and ad hoc network operators, customer care support centres, security (e.g., certification, key distribution) authorities and guarantors, regulatory bodies for spectrum harmonisation and even the IPR-related industry and community.

Consequently, additional research priorities appear in business infrastructure context: it is imperative to be able to quantify the viability and sustainability of a business model, especially in relation to disruptive technologies that will be developed under the European Community umbrella. Indeed, the SRA's user-centric vision should propagate onto business strategies that maximise the value for the end-user, whilst minimising the cost for this value creation. This is particularly in line with the SET Concept that stresses the need for Integrated Solutions and not specific technology research in order to ensure the European leadership in the technology domain: an integrated solution that addresses business-related aspects and allows to quantify the end-user value in the technology adoption is a differentiating factor for the European Research.

In particular, mobility and mobile e-commerce will require radically faster processes for setting up new business relationships. Time-to-market for a new type or instance of a value network must be cut down to a fraction of what it is today. This requires a streamlined approach for taking into account, e.g., automated service provider discovery, negotiation processes and contracting, as well as adoption of micro-payments and streamlined pricing.

7.2 Rationale and Objectives

The main question regarding business issues of current and future wireless systems concerns how to maximise the potential of the technical change in terms of business objectives. However, a knowledge gap exists as to the degree to which economic, financial and organisational aspects are integrated with technological models in innovation trajectories.

One example of this gap can be found in the different level of maturity between the technical approaches for building the functional architecture and the financial approaches for building the business architectures and models.

Hence the need arises for the adoption of new modelling methodologies for business model estimations. These new practices should address the specific requirements set forth in the vision paradigm, and should allow efficient value vs. cost estimations for different stakeholder financial relationship scenarios.

The modelling practices should relay on the domain class, which is instantiated for any traditional or new stakeholder. **Error! Reference source not found.** represents a simple domain class in pictorial form. The domain is intended in a business sense; its attributes are:

- The ownership: e.g., a wireless network operator
- The drivers: e.g., the wireless network operator's business drivers relate to managing users, their profiles and the SLA to which they are entitled
- The domain characterisation (from the business viewpoint): e.g., for a wireless network operator, billing, subscription management, AAA rules

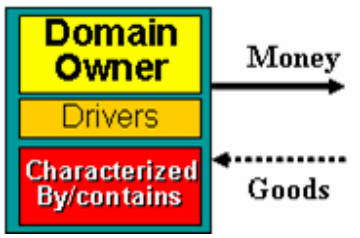

Figure 7-1 Domain as a basic building block

Note also that a domain interfaces with other domains. The interactions are in terms of paid money versus received goods (e.g., equipment, services). **Error! Reference source not found.** below represents an example business application, in which only three domains are identified: the wireless network operator, the wired network operator, and the application or service provider.

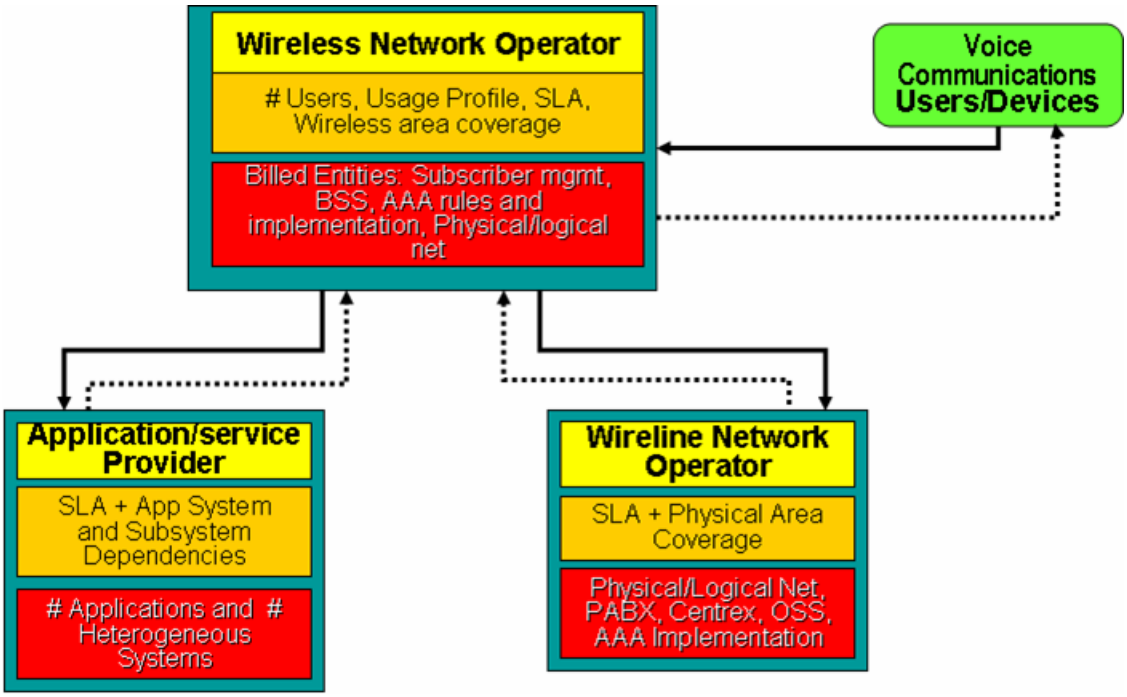

Figure 7-2 Example of a business application with three domains

The domain concept is a means for simple representation of financial transactions between different stakeholders in today's well-established business situations.

This approach is somewhat limiting for treating future mobile business, where the seamless end-user experience is at the centre of the overall picture and where multiple simultaneous business agreements may take place between classical and new stakeholders. The domain building block (e.g., class) should undertake significant modifications in order to fulfil the vision paradigm and consequently reflect the business expansion for accommodating the role of new stakeholders. Examples of the domain class extension are:

- Capability to have concurrent and or complementary business relationships with other domains
    - Example: a peer-to-peer service provider may experience business relationships with its subscribers, with an infrastructure operator, with a wireless network provider, with value added service providers, with advertisers, etc.

- Capability to manage more complicated business relationships with a peer domain
    - Example: a manufacturing domain owner may undertake third party relationships for subcontracting whilst granting manufacturing licenses or IPR royalties
- Construction of a dedicated user domain class, in conformity with the user-centric vision. Specific aspects should include:
    - Support of seamless and simultaneous connectivity to different domains (e.g., wireless operators, wired operators, local residential connectivity, etc.)
    - Simultaneous accessibility to services from different service providers (e.g., having a phone conversation during a NetMeeting connection, the two services being provided by different domain owners)
    - Complex connectivity conditions (e.g., simultaneous roaming with different network operators, sensor network connectivity)
    - Different simultaneous connectivity and service consumption situations (e.g., audio and video streaming with different media transport supports)

Final objective: consolidating and disseminating business architectures and modelling practices that allow a quick pre-estimation of the business viability and sustainability that can result from a novel enabling technology. Such practices could prove extremely useful if implemented in IST across a wide range of projects.

7.3 Research Priorities

The priorities that need to be considered are:

- Consolidating the modelling approach and practises after wide consultation with worldwide stakeholders (both traditional and new)
    - This would influence the SET “Trust axis”: Stakeholders like network operators and service providers must maintain their security domains, whilst avoid becoming liable for new security breaches.
- Prototyping and piloting vertical market-specific light-weight value-oriented networks.
    - In the SET framework new network topologies would be considered. In this respect new ecosystem topologies may appear as well, leading to the need of modelling the value proposition in different contexts.
- Research into value networks based on non-monetary compensations (e.g., social agenda for end-users, brand lift for manufacturers and operators, etc.)
    - A practical modelling tool becomes necessary for helping understand what constitutes value and how value can be optimised and leveraged on a daily basis. This priority is in close relationship with the SET multidisciplinary and multi-industry orientation.

- Specific research into peer-to-peer mobile e-commerce
    - Peer-to-peer is not just a communication support: it implies new tenets in regulation of economic transactions. Its impact on the value chain and on traditional stakeholder business opportunities must be assessed and quantified. This priority in line with the SET vision.
- Case studies on highly successful real mobile e-commerce. Posterior verification of the capability of forecasting the success of these case studies
    - Business infrastructures modelling practices need 'calibration': Specific parameters, variables, information models must be consistent in a wide variety of representative cases.
- Comparative techno-economic analysis of new competing radio technologies and their specific environments (e.g., local, wide-area, residential, sensor-based)
    - Two basic SET tenets are simplicity and efficiency: These reflect onto viability and sustainability of the underlying business relationships. Only a quantitative techno-economic analysis can allow such assessments.

In order to consider the above priorities and quantify market and value impacts, suitable software tools need to be identified or constructed.

7.4 Applicability to the eMobility Technology Areas

The above description refers to a general approach and related formal tools for quantifying the value of a telecom system to the different stakeholders. Indeed, the 'Business Infrastructure' approach can provide processes and practices to evaluate the viability and sustainability of scenarios and use cases that will be addressed in the eMobility technical and strategic tenets. In the following it will be shown how the 'Business Infrastructure' approach can be instantiated across the main SRA research axis.

7.4.1 Business Infrastructure application to 'Trust and Dependability'

Trust implies the following main issues (non-exhaustive list):

- Terminal ID authentication and verification
- User ID authentication and verification
- ID federation across terminals and networks
- Access right management and consequent secure communication

Typical stakeholders in this domain are, e.g., ID guarantors, biometric chip manufacturers, secure communication service providers, etc. The typical metrics for evaluating the viability of Trust are, e.g., solution scalability, solution cost and clearness in establishing the liabilities of the different stakeholders. The 'Business Infrastructure' approach can formalise and model the above metrics and quantify the impact on the business relationships among the stakeholders.

7.4.2 Business Infrastructure application to 'Ubiquitous Services'

From the ubiquitous services perspective, tenets and research priorities, it stems that service management and related network support functions can be pushed more and more towards the network edges (e.g., gateways and even end-user devices). Irrespectively of the service provisioning architecture and topology, service providers and application developers need to maintain their control points, in order to grant DRM policies, customer support and billing procedures to their customers.

New stakeholders could appear in this respect: for instance, the emergence of intermediaries like portal providers, portal personalisation service providers and others. In such context it becomes important to evaluate and quantify whether new business opportunities exist, in order to ensure the most cost effective service consumption procedures to the end-user via the most appropriate terminal.

Typical metrics for evaluating the viability of ubiquitous services are, e.g.,

- Solution scalability
- Speed and easiness of service deployment
- Cost of media servers
- Cost of Service Level Agreements

Again, the 'Business Infrastructure' approach can formalise and model the above metrics and quantify the impact on the business relationships among the stakeholders, including the newcomer ones.

7.4.3 Business Infrastructure application to 'Ubiquitous Connectivity'

Ubiquitous connectivity implies the inter-working of, e.g., wide area networks (WAN), metropolitan area networks (MAN), local area networks (LAN). These are different environments, from the technical, management and business viewpoint. Lines inside WAN, MAN, LAN can be owned or leased, thus implying different impacts on the system cost and billing models. Additionally connectivity implies roaming, and consequent complicated roaming relationships based on

different business and technical metrics. In the connectivity domains many diversified stakeholders play prominent roles:

- Network providers owning different domains in the WAN, MAN, LAN spaces
- Inter-domain gateway providers
- SLA and O&M tool providers

Each stakeholder must ensure positive and sufficient Net Present Value (NPV) for its system. In this respect, each cost variable and its sensitivity must be taken into account. The 'Business Infrastructure' approach must provide modelling tools for assisting in this exercise.

7.4.4 Business Infrastructure application to 'Radio Access'

Specific issues in the Radio Access framework go well beyond classical radio design. Topics like 'self-organising network topologies and operatorless radio access networks', 'cognitive and spectrum-agile' radios and 'frequency sharing' imply new control points, in order to guarantee ubiquitous coverage and capacity and ultimately, guarantee the QoS to the end-user.

New stakeholders would probably appear: for instance, the opportunistic spectrum use implies a strict control on the spurious emissions, at both terminal and infrastructure side. Again, a liability issue appear: an operator is liable for providing radio access in its assigned frequency spectrum; is such operator equally or even more liable when uses additional frequency bands on secondary basis?

The role of a radio access network provider can have a significant evolution, according to new revenue opportunities and to new responsibilities to the end user. Again, quantifying the business aspects of the future radio systems and their complexity is of paramount importance, for helping the relevant stakeholders quantify the expected ROI, thereby deciding the most appropriate investment strategies. The 'Business Infrastructure' approach must provide modelling tools for assisting in this exercise.

7.5 Innovation / Exploitation

The described framework enables new business processes while getting the most out of the business applications and technology already available. The essence of this innovation is transforming disjointed data and functionalities into a cohesive business process that spans multiple systems and domains (as per Figure 7-2). Thereby, the Business Infrastructure methodology is an application that offers a methodology and toolset for the development, deployment, and management of user-centric composite business cases. Exploitation opportunities for system developers and business experts rely on the Business Infrastructure

model-driven, pattern-based approach that allows the creation of new business solutions according to specific needs. Below, two particular cases are illustrated.

7.5.1 Multi-Service Operators (MSO)

Cable and wireline MSOs are now entering the 'Fixed-Mobile Convergence' field: they want to offer seamless mobility services, by putting the user at the centre of a portfolio of services (e.g., quadruple-play services) that are automatically tailored to their environment. MSOs wish to cover all of a subscriber's communication demands whether they are at home, at work or on the move: services that will be delivered on multi-mode devices that provide the same interface regardless of the product being accessed.

Two issues are key for MSOs seeking to offer seamless mobility: the first is the core network architecture and the second is securing service agreements with cellular service providers. These issues must lead to the creation of a business requirement set to provide robust, secure, SLA-compliant network interconnect mechanisms. The Business Infrastructure methodology is key in this process.

7.5.2 Small-to-Medium Size Enterprises (SME)

SMEs have specific constraints in order to drive their business efficiently. Specifically, SMEs must be able to quickly answer 'Request for Proposals' (RFP) for securing bid opportunities. The following variables must be considered:

- Time-to-market
- Solution cost
- System scalability
- System management flexibility
- Revenue models

The Business Infrastructure methodology makes it easier for SMEs to manage and accurately address large RFP or bid opportunities from inquiring stakeholders, because it allows saving time and money in the business quantification process.

8 Frontier and Multidisciplinary Research

8.1 The Perspective

R&D history is full of success stories concerning ideas that were considered “wild” by the time they were proposed and that later on have constituted a huge success. Optical fibres (i.e., the notion of guiding waves without metal) and operating systems based on windows and a mouse (i.e., interacting with a computer without the need of using text line commands) are just two of the examples. Hence, creating disruption is part of the essence of research and development, and only by such a perspective can society develop further – by creating new products and markets, and by reaching users with new services and technologies. Obviously, there are also many failure stories, many of which are not known.

Unfortunately, there is no measure of success that can be used. At the start, it is virtually impossible to know if an idea will be successful and it will make the difference, or on the other hand, if it will be just a waste of resources. But this is what R&D is all about, namely dealing with basic and fundamental areas. Furthermore, by neglecting basic and fundamental R&D activities, one will be jeopardising the future, since more applied R&D is always based on results coming from the basic and fundamental one.

In the next decade, mobile and wireless applications and services are likely to become pervasive, with a widely spread use of devices everywhere. Computation and communication capabilities will be radically integrated in a great variety of different everyday objects, from simple sensors and interactive appliances (e.g., cards, rings, eyeglasses) via pocket and lap-sized devices to wall or table screen working areas. Technology will undergo a transformation, from an expensive, highly visible, hi-tech approach as in early cellular phones, over the current state, where practically everyone owns a mobile phone, to a disappearing technology that is present everywhere and taken for granted.

In the area of mobile and wireless communications, one should aim at farfetched objectives for basic and fundamental research that do not constitute an approach similar to the Olympic Games motto ("Citius, Altius, Fortius", standing for “Faster, Higher, Stronger”) applied to current systems and techniques (i.e., more of the same, but just better). Such a perspective challenges many of the current paradigms in mobile and wireless communications. But it is felt that Europe does need to explore ideas beyond the usual topics being currently presented and discussed in technical meetings; only by doing this, will the European industry continue to play a leading role in the area

of mobile and wireless communications, moving from a decreasing manufacturing role to an increasing conceptual one.

In what follows, topics are split into major groups:

- **Frontier research**, addressing basic and fundamental topics in the specific area of mobile and wireless communications, and in telecommunications in general;
- **Multidisciplinary research**, bridging mobile and wireless communications with others unrelated to telecommunications, namely those identified in the EC proposal for FP7.

8.2 Frontier Research

8.2.1 Vision

Frontier research will continue to open up new options to meet present and future requirements. For mobile and wireless communications, further improvements in user-experience, transparency and autonomy are in need of better solutions.

Frontier research drawing on several disciplines is, e.g., expected to overcome the current dependence on traditional input devices, such as keyboards, and to offer more efficient power-management and answers to social computing application issues. In addition, in order to understand mobile users' behaviour, multi-disciplinary work for learning and behaviour-modelling is required.

8.2.2 Rationale and Objectives

The focus of the eMobility Platform is not frontier research. However, in this domain some basic and fundamental research can have a very profound impact, and inversely, problems do arise that may need additional research. The objectives of frontier research are to explore new fields in the area, as well as to extend the borders of mobile and wireless services and applications.

8.2.3 Research Priorities

The priorities are to be seen as a complementary activity of frontier research carried out in other frameworks and objectives. These activities are needed to fill in gaps and to transfer research results.

While much progress has been made in facilitating the interaction with equipment and the services, the present solutions remain a major bottleneck for new applications and services. Terminals without keyboards and innovative display techniques will change the user experience

and enable new applications. The fundamental developments in sensor technology and sensor networks in general will drive the new interfaces towards more contextual computing. In the future, input functions could, in fact, be thought controlled. However, frontier research is needed not only for hardware innovations, and in many cases new modes of interactions in the software are even more important. The emerging social computing on mobile device platforms requires fundamental multi-disciplinary research combined with network theory, game theory and computer science.

The limited battery-power remains a major constraint in mobile technology. While improvements have been made, the power-management problem has to be addressed at the system level and requires fundamental innovations not only at the hardware level, but also in energy-efficient software where frontier research has a great promise, but is also very challenging.

The work on identifying risks due to radio emission has so far been inconclusive. While it may prove to be of no concern, a better understanding of the biological effects would help to avoid problems and provide peace of mind.

Other areas can be identified, as well. The list of ideas presented below does not carry any concern about how they can actually be implemented, or what is the path to follow. It is a list of ideas that it is considered to be worthwhile to explore. Moreover, some of these ideas are more farfetched than others, which do not constitute a devaluation of some over the others. The following topics are identified:

- **Wireless protocol (WP)**: a new protocol approach, replacing IP (in the access), designed for all the coming features of mobile and wireless communications. Basically, it is a Post IP/Clean Slate Design/Clean Sheet approach, addressing a new communication environment related to a new communication stack to fulfil requirements that are currently only hardly addressed in the IP-based infrastructure (e.g., full mobility, QoS, full broadband capabilities, efficient usage of network resources (radio and transmission), realistic security framework, self-organising, self-healing, and self-configuration). It is requested that the operators have a significant influence in this architecture, and the work should cover revolutionary approaches as well as an evolutionary migration path to develop a new environment in a long term perspective.
- **User identification**: the capability of users being identified only by some kind of RFSIM (Radio Frequency Subscriber Identity Module).
- **Submillimetre waves**: exploration of propagation and channels at frequencies in these ranges.

- **Inter and intra-device communications**: replacement of wired communications by wireless ones for these types of applications.
- **Information and content deposits**: users having access to all their relevant information and content via a wireless terminal, without actually carrying any of it.
- **Network information theoretical limits**: re-evaluation of these limits for new approaches of communication systems.
- **Theoretical limits of cooperative communication paradigms**: study of the link and network capacity gains of cooperative transmissions, involving several terminals.
- **Theoretical limits of self-organising networks**: study of ad hoc network capacity limits for asymmetric networks, in the number of origin and destination nodes.
- **New codes**: development of codes for networks, broadcast, and quantum applications, among others.
- **Intelligent applications**: use of Artificial Intelligence (i.e., smart agents) to be put into mobile devices, allowing independent communication among devices (i.e., machine-to machine), including features like context awareness, and enabling pro-activity in mobile devices.

8.3 Multidisciplinary Research

The EC has identified the priority disciplines for R&D in FP7, which are, besides the one including mobile and wireless communications (Information and Communication Technologies):

- Health
- Food, Agriculture and Biotechnologies
- Nanosciences, Nanotechnologies, Materials, and New Production Technologies
- Energy
- Environment
- Transport
- Socio-economical Sciences and the Humanities
- Security and Space

Multidisciplinary research, bridging the gap between mobile and wireless communications and other sciences, should focus on the above listed ones. But this list is not an exclusive one, and other areas are also of interest, e.g., clothing and footwear, glass, construction, domestic appliances, entertainment, media, banking, distribution and logistics, and sports. A brief analysis of some of the areas follows, identifying problems to be addressed and solved, as well as constraints that need to be taken into consideration. Some of the inputs to this section originated from discussions and presentations in the eMobility **Workshops on Shaping the Future of**

Mobile and Wireless Communications. Detailed information is available at the eMobility website: http://www.emobility.eu.org.

In the **health** area, one can attempt to group technologies into two groups: those used for disease diagnostics, and those related to the provision of health care, namely to elderly (a growing sector in Europe) and disabled people, i.e., Inclusion. In the former, there is quite an industry in the sector, developing instruments and devices for that purpose; however, wireless communications can help in providing new means for diagnostics, namely via the use of sensors and RFID (together with micro-robotics) to be injected into the human body (e.g., orally or via the blood stream), which can provide a more detailed and accurate analysis of internal organs; at a later stage, one can also foresee the use of wireless communications together with these devices for performing micro-surgeries. As for the latter, there is a whole world of applications to be developed, many of which do not face any key technological challenge, but rather, require that mobile and wireless communications become more reliable (the probability of failure of communication may not be acceptable in many cases), integrated (the need for communication where and when ever required, with any device), transparent (the easiness of use is a must), trusty (medical doctors need to believe that the technology can in fact be used for the purpose in mind), and adapted to the various perspectives (patients, relatives and friends, and professionals). A few examples of applications, supported on or integrating mobile and wireless communications are: measurement of the health state and transmission of an alarm in case of a problem; location based services (both indoor and outdoor), for people carrying a wireless device; integration of all devices in a hospital into a wireless network. In all of this, the patient should be the main focus and concern. Additionally, the provision of health care in developing countries, with special needs and dedicated solutions, should be considered as well, as this is an area in which mobile and wireless communications can make a huge difference. Other aspects may also be identified, which are not technical ones, but which do need to be taken into consideration: privacy, security, ethical, legal, and safety. Moreover, in the case of people with disabilities, many times, an extensive use of mobile and wireless communications can be enabled just by considering their requirements at an initial stage of the development, with very simple solutions and without extra cost or effort. Finally, one can go further, and consider applications that do require a real multi-disciplinary research with other areas, like the use of wireless communications for establishing communications in the nervous system, when this is no longer possible due to an accident or any other reason.

The area of **environment** is very much linked to wireless sensor networks, but not confined to them. Thus, aspects like minimal invasiveness associated to smaller size sensors, longer life batteries, support of a broad spectrum of probes and systems, ad hoc networking, ease of

installation and maintenance, autonomic communications, and self-organised networks, are at stake. Aspects related to disaster prevention should be taken into consideration as well, as mobile and wireless communications can/should play a key role in this area. In some cases, the economical challenges may be larger than the technical ones. But, related to environment as well, one should include the design of more efficient systems, in terms of power consumption (hence, putting less pressure on longer life batteries) and of radiated power (not only decreasing interference among systems, but also lowering the overall electromagnetic fields to which the population is exposed to). Somehow related to environment as well is the development of wireless power, i.e., the capability of providing power to a device without any wires or batteries.

Transportation is an area where mobile and wireless communications have already an impact, which tends to become more and more important. Perhaps, this problem has been approached more from the perspective of automotive industry (e.g., installation of terminals in cars as a basic feature in the automotive industry), neglecting other important aspects like traffic control, fleet management, and value added services, namely those related to real time applications (e.g., personalised traveller support services). Mobile and wireless communications could/should play a role in creating Intelligent Transport Systems, from which a few examples follow: by embedding ambient intelligence into asphalt and concrete, road infrastructures will become advanced telecommunications enabled, establishing the conditions for the deployment of a whole new world of transport-related applications; infrastructure-to-vehicle communications, enabling telecom operators, public authorities, and transport infrastructure operators to play a key role in the pervasiveness of telecommunications in general, both as infrastructure deployers and as providers and/or enablers of multiple services, directly or indirectly related to transport; seamless traveller support personalised services must be possible across hardware platforms and across transport modes, without the need for travellers to possess a specific device; application of RFID in freight transport, not so much from the application or functional viewpoint, but from the perspective of cost reductions, which is certainly linked to embedded systems and nano-electronics. A clear challenge in this area is the creation of games for travellers that interact in real time with the environment being crossed by the transport: this will really require many disciplines to interact among each other, i.e., the game industry, telecoms operators, infrastructure operators, and transport industry, among other (e.g., electronics and consumer industries); such a game requires location based services, real time interaction among players, a huge demand on the network for the provision of information, and so on.

Studies from a **social** approach on the **perspective** that users have on mobile and wireless communications clearly indicate that more and more services and applications, as well as easiness of use, are the key issue. One of the starting points is the study and understanding of

everyday social practices, as well as people's interaction with the various tools that surround them, and the way they make use of the body and cognition in the interaction with the world. One of the trends that is already observable in the Internet is that everyone will become a contents provider, hence, peer-to-peer will play a major role in the future. This will clear impact on mobile and wireless systems and networks, e.g., by requiring a very high data rate for uplink (and not only for down link, as initially thought), as well as large information and content deposits (as already mention in the previous subsection). But also, will put pressure on the development of tools and services in order to help everyone to become a service and/or content provider. Additionally, the impact of an increased use of mobile and wirelss communications on people behaviour and social relations needs to be addressed. The development of software applications that can model and predict social behaviour, based on inputs coming from social sciences, is something that has already started, and should be progressed further, namely focusing on mobile and wireless communications. Another issue in this area is the usage of multi-sensory information, making use of all human five basic senses, and also sensing the mood and state of mind of the user; this will create many new opportunities for devices, services and applications, which need to be accommodated by mobile and wireless communications systems and networks, enabling the user to have a totally different interaction with both the environment in which is located and other people, either existing in the environment or with which will establish communication via the device, based on the user's needs, wants or drives. Virtual reality may play a role in here, and the cooperation between the clothing industry and the mobile and wireless communications one for the development of multimedia communication clothes may be an example. Also, the development of multipurpose mobile terminals, and the Incorporation of terminals in common use objects, will be a must, requiring a strong interaction among various industries. Furthermore, the area of education and training cannot be forgotten, and the use of technologies based on mobile and wireless communications will certainly gain an increased role. Perhaps, more farfetched, will be the use of mobile and wireless communications for creating virtual presence or telepathy.

Security is very much related with, e.g., the banking business, among others. In this case, the use of mobile and wireless communications may be essential for the development of new services, which however, will require that the communications systems present some features that are not available yet. One can think of a situation, in which a bank knows from a user's context and profile his/her preferences and sells the appropriate product/service to that user. In general, many services and applications can be thought of that are for the real benefit of the user: the inclusion of a trusty voice recognition mechanism in mobile terminals may ease the development of many applications based on mobile commerce requiring payment (challenges on signal processing, among others); real roaming of services and applications (which in fact

currently only exists for voice) will clearly make life easier for users travelling to other countries (challenges on interoperability, among others); use of biometrics for user identification, leading to secure exchange of information (challenges on sensors, among others); development of payment methods that are secure, easy to use, and not expensive, really enabling to use the mobile terminal as an electronic wallet (challenges on applications development, among others). Other aspects related to security are those regarding crisis management and the import role that mobile and wireless communications can play after disasters (coming from physical causes or terrorism); approaches based on ad hoc, self-organising, and self-healing networks, and on self-configuration mobile devices that survive from a disaster, are just a few of the aspects that need to be addressed.

Entertainment is an area that, sometimes, is not taken seriously by researchers, although it is an area that really involves everyone in the daily life. Among the many activities related to this area, one can find sports and games. In sports, the use of mobile and wireless communications for collecting and transporting information, enabling its analysis in real time, is becoming increasingly important, e.g., wireless systems are needed to measure time, location, and body parameters, terminals being required to be accurate, light weight, of high capacity, and long duration, while systems are constrained by a high capacity to deliver information under the operating conditions. Challenges in this area are clearly not only on sensors and terminals, but also on systems and networks. Games can also be very challenging towards the requirements and constraints they put to mobile and wireless communications systems. Many times, tiny aspects of communication systems and devices may reveal to be crucial when games are at stake: for example, ensuring that the same sound is obtained in any terminal where a given game is played can be very important, although not faced as a challenge for R&D; of course, this has to do much more with standardisation, and competition among manufacturers, but nevertheless, keeps being an issue. Middleware plays another important role, as it may enable to develop games that are totally platform independent. But, other aspects previously mentioned in this subsection, are also of impact in games; e.g., virtual reality, location based services, terminal size (here, the perspective can be contradictory) and capabilities, easiness of use, and peer-to-peer communications.

Many of the topics and challenges identified in this subsection are already listed in the previous chapters, under the respective technical area, but, the fact that they are listed here shows that there is an increasing need to bring into R&D in mobile and wireless communications the expertise and views of researchers from other areas, many times considered to be “orthogonal” to telecommunications. It seems also clear that the SET Concept is part of the answer to many of the problems previously identified.

9 Accompanying Measures

9.1 Non-Technical Barriers

Future communications will be truly ubiquitous – capabilities, applications and services delivered over interworked heterogeneous wired and wireless networks by multiple diverse service providers who will not own, nor necessarily even exercise management control, over these networks. Such communications will have major societal implications, impacting all spheres of life and social interactions.

Potential impacts will include *inter alia* the areas of:

- e-Governance
    - Communications between state and citizen, with impacts upon the democratic process itself, as well as, on delivery of services by the state
- Environmental & Personal Security
    - Provision of always-on sensing and monitoring to contain a wide variety of natural and man-made threats to the human environment and personal health and safety
- Societal Interactions
    - Interpersonal and person-business relationships and behaviours will change as new technologies permit new methods of interaction and socialising
- Industry Efficiencies
    - Always-everywhere communications will allow the introduction of new business models, not simply bringing efficiencies, but revolutionising value chains and industry operations

9.2 Rationale and Objectives

As such, many factors will affect technology requirements and inversely affect social requirements. The interaction of technology possibilities, requirements and society is a two-way process:

- Desired societal outcomes can give rise to requirements on technology
- Unfettered technology evolution, without consideration of implications, can give rise to highly undesirable societal outcomes

To create awareness of these evolutionary processes taking place in very different frameworks (e.g., education, social policies, regulations, business, laboratories) a continuous effort is required.

Further, an effective combination of industry and regulatory policies, research and commercial pull-through of R&D is required if the fruit of the research requirements described within the Strategic Research Agenda is to be realised in terms of economic prosperity and growth for Europe. Without an effective ecosystem the SRA will fail to achieve this goal.

Supporting measures that address these complementary issues are essential. Success in these areas is critical to the existence of a healthy society and a vibrant ICT industry in Europe in the 2015-2020 timeframe.

9.3 Objectives of the SRA: Non-Technical Barriers

9.3.1 Objectives

The key rationale for the e-Mobility Technology Platform and its Strategic Research Agenda is fundamentally to create technology that will enable economic growth and societal prosperity for Europe. Good technology resulting from such research, if pulled through with appropriate business applications, will result in economic growth, and prosperity for a wide range of European industries, not simply the communications or ICT industry.

The Economic Potential – Economic and industry growth will occur if there is significant technology adoption by business to create efficiency and productivity gains. Such gains may take two forms:

- **Incremental gains** through technology offering improved efficiencies in existing processes
- **Step-change gains** through technology enabling completely new business processes, and thereby revolutionising the value chain

Both are important. The latter has potential for greater and deeper impact and economic benefit, but equally is much harder to secure due to cultural aversion to such changes amongst incumbents. Such potential gains will however be recognised as early adopters are seen to benefit. Such potential offers not only benefits for other industries, but also for telecommunications operators, through the introduction of new services and applications, and for manufacturers, to support these new applications and application and industry specific opportunities.

9.3.2 The Economic Challenge of Today's European Environment

Existing Markets – Recently, in Europe and globally, many new wireless and mobility technologies have been rapidly emerging. Traditionally the telecommunications industry has secured economies of scale through international specification and standardisation – indeed, this was the key in the 1990s, through the formation of ETSI, 3GPP and 3GPP2, to the transformation from national to truly European and global telecommunications companies. GSM and 3G are in this respect the classic exemplar.

New Markets – The significant future economic potential resides in existing, as well as in new markets. In Europe today, the significant scale field trials needed to prove technology in real applications and create these new markets rather than leaving markets open to overseas competitors, who are often actively supported by their Governments who have prioritised these new ICT markets

A Changing Environment – Compared to the past, the combination of evolution of a European policy environment towards more technology independent concepts which may lead to nationally fragmented markets and lower economies of scale together with the consequences of the telecom industry downturn, is reducing opportunities for the pull-through of EU R&D compared to, say, the early 1990s (see Figure 9-1). However, EU R&D activities provide opportunities in global competition for global standards and products. This applies particularly in the area of wireless, where lack of harmonised spectrum and systems directly restricts market size. The pan-European spectrum was a key enabler of the success of GSM.

Industry Policy – ICT is today a globalised industry, with minimal geographical barriers. Market liberalisation has removed the concept of industry promotion in many member states, whilst in others it still exists in camouflage. Even in such countries however the focus of much government policy is on reducing consumer costs and supporting consumer demands, resulting in increasing regulatory burdens on industry. Overall across Europe industry policy is poorly linked with R&D and such linkage is different in different member states. Here Europe is in strong competition with Asian countries This situation must be acknowledged, studied, understood and new approaches have to be identified e.g., by creation of lead markets, the use of structural funds and public procurement means where appropriate if the benefits of strategic research are to be realised as economic gains for the European economy.

From Today to Tomorrow – In today's political and regulatory environment and with respect to increased global competition as just described, R&D pull-through is harder & less effective than ten years ago. However, collaborative research provides opportunities for

developing new technologies and setting of global standards at a time when the industry has globalised and European industry is facing seriously increasing competition from Asia. In Europe funding from commercial organisations for R&D application pilots and similar mechanisms for research pull-through is mainly available for proven business cases, but for little else, potentially threatening Europe's global competitiveness in the longer term.

This is not to say that Europe should move backward, or should re-adopt its own historical policies, which are now being pursued in Asia; this would be both inappropriate and ineffective in the 21st Century. Rather, Europe should move forward, with new policies that can achieve the goal through new approaches. However, significant work is needed, alongside the proposed SRA research activity, to identify effective mechanisms that will achieve the desired goal of leveraging the fruits of the research to create major new markets, invigorate other industries and thereby stimulate significant economic growth.

1980s	**GSM-focussed R&D** mandated spectrum, mandated regional technology & standard
1990s:	**3G and short range wireless** consensus licenced spectrum & global standard(s)-3G unlicensed global usage-Short range communications
2000s:	**Beyond Generations?** B3G, 4G – the Asian thrust, high bit rate initial push has now embraced EU perspectives of interworking Multiple new air interfaces, aimed at low cost (Intelair) Sensor networks – wireless embedded everywhere
2010:	**Spectrum liberalisation & trading** There are still intentions for harmonised spectrum for certain applications, however for technology independent allocation Buy spectrum & use whatever technology wished
	Implications Economies of scale through SDR, but only if the overhead costs of SDR are almost zero Changes in business models are inevitable

Figure 9-1 Exhibit A, The Change in Europe's Wireless R&D Context 1980-2010

9.3.3 The Social Challenge

Changing Behaviour – The diversity of Europe is its strength. Politicians and EU Commission have ignored this cultural diversity at their peril. Polite and appropriate behaviour in one country may be unacceptable in another, even across Europe; personal space has differing definitions, normal topics of discussion vary. Despite this, the ability to communicate anywhere and anytime, via phone or texting, has changed everyday behaviour – for example, no need to take a map, if you can call from the car and ask for directions. Less need to plan ahead if you can always reach friends by phone.

Future Changes – Future technology will potentially allow the user to identify someone with similar interests as he passes in the street, to locate them across a city. But what interests are acceptable to society or are deviant? How may this vary between countries? What about privacy and anonymity? What new forms of productive, or aberrant social behaviours could such capabilities encourage?

The Role for Social Research – Traditionally scientists and engineers have left the application of their technology to others and neglected consideration of its potential consequences. The classic example is the reference “I am become death” from Robert Oppenheimer, describing the perspective of the creators of the atomic bomb as they contemplated the prospect of what the technology would result in. Arguably the importance or necessity of such considerations is related to the scale of its potential impact upon human society.

Social Research in Communications – Little research has traditionally been undertaken on the future impact of communications. The unforecast success of texting and the still uncertain future of today’s hoped-for-killer-application mobile-TV are examples reflecting this; the growth of the adult content industry facilitated by the Internet is another. Yet communication is a fundamental human need and activity and as we move into an era of personalised devices and services, of context awareness, and ubiquity, technology has the potential over a generation to profoundly change an inherent aspect of the historical personal psyche. Surely this issue is potentially as profound as GM crops – the latter impacts our environment, the former impacts humanity directly.

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