Chapter 13

I-CENTRIC COMMUNICATIONS

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Abstract: This chapter introduces the rationales, the framework, and the architecture of I-centric Communications, a new paradigm to design and to develop telecommunication systems. I-centric Communications has been proposed by the Wireless World Research Forum (WWRF) working group 2 based on numerous contributions from academia and industry world wide.

Key words: I-centric communications, 3G beyond service architecture, personalization, ambient-awareness, adaptability

1. INTRODUCTION

In 2000, the IST Programme Advisory Group (ISTAG) published a vision statement [ISTAG] for Framework Programme 5 that laid down a challenge to:

‘Start creating an ambient intelligence landscape (for seamless delivery of services and applications) in Europe relying also upon test-beds and open source software, develop user-friendliness, and develop and converge the networking infrastructure in Europe to world-class’.

Ambient Intelligence stems from the convergence of three key technologies: Ubiquitous Computing, Ubiquitous Communication, and Intelligent User Friendly Interfaces. Ambient Intelligence implies a seamless environment of computing, advanced networking technology, and specific interfaces. It is aware of the specific characteristics of human presence and personalities, takes care of needs and is capable of responding intelligently to spoken or gestured indications of desire, and even can engage in intelligent dialogue. Ambient Intelligence should also be unobtrusive, often invisible: everywhere and yet in our consciousness – nowhere unless we

need it. Interaction should be relaxing and enjoyable for the citizen, and not involve a steep learning curve. [ISTAG]

The prerequisite for service integration is global connectivity, based on a fast developing web of interconnected communication networks, comprising both fixed and wireless networks. In addition, the provision of a global service infrastructure, based on network-independent open service platforms is the other fundamental prerequisite, hiding the complexity of network diversity, and allowing the fast and efficient creation, provision, and management of future services.

Ambient intelligence requires appropriate communication services and information systems that adapt automatically to the human communication behavior. Users have to be supported in order to cope with the huge amount of information available and the increasing complexity of (communication) services. In addition, the continuous reachability of people due to advanced mobile communication requires adequate means for information filtering and communication control.

2. MOTIVATION

It is common understanding that future services will have to adapt to individual requirements of human beings [BoV01]. The communication system has to provide the intelligence required for modeling the communication space of each individual adapting to its interests, environment, and life stage.

I-centric communications considers the human behavior as a starting point to adapt the activities of communication systems to it. Human beings do not want to employ technology. Humans rather want to communicate interacting in their individual communication space.

Introducing communication systems that follow the I-centric vision can only be an evolutionary process. A transition phase between 3rd generation telecommunication networks towards 3G beyond (3Gb) systems is needed. 3Gb is anticipated as enabling platform for user-driven service provisioning incorporating a variety of access mechanisms, mobile service execution environments, and a huge amount of mobile services [Arb02b].

IP-based technologies that allow the integration of available heterogeneous networks into a single platform capable of supporting user to roam between them, while not interrupting active communications have already been introduced [FSAN]. This development will be assisted by the rise of new mobile devices maintaining various access interfaces that will allow connectivity over a range of providers and technologies. Finally, the emergence of a variety of access devices will dictate the liberation of users

from a single device and allow service mobility between devices and networks [Mohr02, Arb03a].

2.1 Trends towards 3Gb Telecommunication Systems

The driving forces for today's telecommunication world have been the growth of Internet (especially broadband internet access at home) and 2G mobile telecommunication. Both are now converging around the 2.5 and 3G networks and services.

From a service perspective, the main difference between 2G/2.5G and 3G telecommunication systems is the new air interface enabling higher transmission data rates. For 3G beyond systems a global consensus exists that a new system architecture needs to be developed. This system architecture has to support a number of new features that have been identified already:

- blurring business roles
- personalized, ambient-aware, adaptive end user services
- augmented environments as part of the ubiquitous communication system
- new networking services: ad-hoc, p2p
- all IP services: always best connected, packet switched, broadband
- diverse access technologies, global coverage, global roaming
- further convergence of voice, data, and mobile communications
- new wireless links (high/low data rate, long/short range)

Beside all these technical trends, a harmonization between different application domains is expected. The integration between services for office and home environments, which has been started already, will continue towards service environments covering the complete communication space of individual users.

3G beyond systems will support mobile service usage irrespective where users are, what kind of terminal they are using, what kind of bearer technology is underneath, and what kind of information has to be delivered.

2.1.1 Telecommunication and Wireless Networks

Started in the mid 90th, telecom markets are still characterized by the convergence of traditional telecommunication services. Many of these services are available today without a harmonized appearance towards the user.

Service provisioning and especially personalization of services is perceived as an upcoming and important success factor. Although, some services offer the possibility of personalization, the support of individual user needs is proprietary, at best. Market analysis has already required future

services to be user-centric. They should adapt to user needs, and to the current situation, the user is in. Traditional communication services, designed for large user groups, are not able to address individual user needs.

Provision of ambient-aware services is the next frontier towards the realization of such concept. Location based techniques are the first to be exploited in this direction, and some operators are offering location-based services in GSM and UMTS already.

Another trend is the introduction of service and content adaptation. In the area of content adaptation, technologies have been developed that allow description and transformation of content in such a way that it can be presented by devices with different characteristics. Research has also been performed on coding algorithms that allow information to be trans-coded in relation to e.g. the current network status. In addition, media conversion is an available feature today and it has been introduced in commercial Unified Messaging Systems already.

Some of the main architectural breakthroughs in respect to a general service architecture have been developed by the TINA consortium [TINA]. The main results are the definition of a telecommunication related business model, an associated session model, and the specification of related reference points. The TINA business model implies a centralized architecture, where components are assigned to fixed domains. In a mobile environment as envisioned for 3G beyond, this approach and the business model itself have to be extended.

2.1.2 Internet Protocol Everywhere

The era of monolithic telecommunication networks with centralized intelligence is developing towards decentralized structures where the borderline between the traditional roles of network provider, content provider, service provider, and user vanishes. This is due to the penetration of network technologies everywhere and by everyone. The integration of these networks pertaining to even different administrative domains is solved on OSI layer 3 by using the Internet protocol (IP).

Another major trend is the proliferation of IP-based devices. End-systems will not only be desktop/laptop computers but also Smart-IP devices. All these devices will be addressable in a global IP communication infrastructure connected via various wired and wireless networks.

Considering these facts, it is obvious that any microcontroller-based device has the potential to be part of the communication space in the future. Wireless networks like Bluetooth, WLAN, or ZigBee enable these devices to be connected to each other without new wires, and IPv6 supports their interconnection by accommodating a massive number of devices. Available computer power and the networks lead to the ubiquitous access to services –

anytime, anywhere, and for anyone. Devising according service architecture is fundamental for future communication systems.

Present communication systems are designed and developed for specific end-systems and for a specific communication service. A vertical design from network technology up to the user interface and device capabilities takes place. Services are kept presentation oriented and each of them has its own way to handle it. Every service is developed for a certain network technology, dedicated to a user community in which individuals are reduced to the common denominator defined by the service designer. The hope is that everybody will buy the service and the associated device. This implies the communication infrastructure engineered to offer the broadest solution. Scalability, performance, and controllability of the network infrastructure are resulting problems.

2.1.3 Service Platforms

Taking emerging 3G business models and value networks into account, services are expected to work in concert of many actors. The 3GPP promotes the possibility to create services on standardized tool sets, e.g. OSA. OSA defines an architecture that enables operator and third party applications to make use of network functionality through an open standardized API. In this way, network complexity is transparent to the applications that are presented independent of the underlying network technology.

Figure 1: Individual communication space

2.2 Vision for I-centric Communications

The communication behavior of human beings is characterized by frequent interactions with a set of objects in their environment. Humans solve the problems of their daily life, e.g. money need to be managed, food has to be bought and to be prepared for eating, movies are watched for entertainment, places are visited and news are consumed, and other people are met. The set of objects, controlled by each individual human, define its individual communication space as shown in Figure 1.

A communication space of an individual is limited: ‘I do not know everybody in the world, I am not interested in everything, and I do not have all necessary devices required by all communication services everywhere at all times’.

Furthermore, individuals are interested in semantic and not necessarily in the kind of presentation of a specific service. Services in an individual communication space have to support the quality of the human senses, and since quality of senses is individual, they have to adapt their presentation to each individual automatically. Services have to adapt to the life stage and the environment of each individual.

Following this view, a new approach is to build communication systems not based on specific technologies, but on the analysis of the individual communication space. The result is a communication system that adapts to the specific demands of each individual (I-centric). Such a communication system acts on behalf of human’s demands, reflecting recent actions to enable profiling, and self-adaptation. I-centric Services adapt to individual communication spaces and situations. In this context ‘I’ means I, or individual, ‘Centric’ means adaptable to I demands and a certain environment.

The rationales above require intelligence in service provisioning in order to personalize, adapt to situational and environmental conditions, to monitor and to control the individual communication space. An I-centric communications system provides the intelligence, which is required for modeling the communication space of each individual by adapting to its interests, environment, and preferences.

The multitude of devices, wearables, different telecommunication technologies, positioning and sensing systems are considered as enabling technologies for I-centric communications. Universal information access (including service interworking, media conversion), flexible management of equipment and facilities, and personal communications [Eck96] form the basis of such systems.

2.3 I-centric Communications – Basic Terminology

I-centric means to take a bottomless look at human behavior and to adapt the activities of communication systems to it. This abstract description of humans' communication activities requires a set of definitions that allow the mapping of abstract requirements (or wishes) to the physical communication environment later on.

All entities, humans are interacting with, will be called objects further on. They can be activated or deactivated by an individual, or environmental conditions, to perform an action according to specific needs of an individual. Objects can represent one or more physical entities performing a certain service.

An object is a logical representation of hardware or software entity, or even a representation of a certain individual, and provides well-defined services from the perspective of an (other) individual.

An I-centric system should support massive numbers of objects and should be tolerant against object failures. The population of objects is always changing because they spontaneously enter/leave/roam the environment and hence the communication space. Already standardized mechanisms for naming, lifecycle, monitoring, fault tolerance etc. have to be taken into account to determine whether they suit the requirements of I-centric communications.

Due to changes in human being's daily live, the amount or the concrete instances of objects are changing over time. Nevertheless, the sum of objects, an individual might interact with form his individual communication space. Objects may pertain to different communication spaces. They can be controlled by individuals, other objects, or services. Individuals can directly ask for a service to be performed by an object, whereas environmental condition may influence the status of objects indirectly. Communication between different individuals takes place by sharing objects of their communication spaces. In this case, objects representing communication facilities in the different communication spaces are connected to establish a physical connection between two individuals. What kind of physical resources are used for the communication is decided dynamically and depends on individual preferences of involved parties, their available communication facilities, and additional ambient information. The process of how to select and activate objects and physical resources underneath is one of the main activities of an I-centric communications system.

Individual communication spaces are growing and shrinking in the time axes based on the individual life stage, personal interests, working and living environments, and the availability of new kinds of telecommunication

services and devices. The size of the individual communication space varies over time due to the appearance or disappearance of objects.

Each individual has only one individual communication space. It contains all objects this individual might want to perform requests on. Objects that pertain to individual communication spaces of different individuals must handle concurrent access from different individuals or must delegate the concurrency control to the I-centric communications system.

2.3.1 Context and Active Context

The context provides the definition of relationships and causalities between different objects of an individual communication space and the individual. A context represents a ‘universe of discourse’ in an individual communication space. Individuals communicate with objects in their environment in a certain context.

Objects may pertain to different contexts (even to contexts of different individuals), because individuals might want to have a certain object involved in different activities.

Contexts are independent from any concrete environment. If an individual wants to act in a certain context this context has to be activated. An active context defines the relationship of an individual to and between particular numbers of physical resources at a certain moment in time, in a certain environment. The activation and deactivation of a context should usually be done automatically just by analyzing individuals’ activities, but an individual should also have the possibility to do this explicitly.

Activating a context means:

- the identification of objects that are required by the context,
- the evaluation of the relationships and causalities between objects defined by the context,
- the discovery of the actual vicinity of the individual to identify physical resources that provide the functionality required by the identified objects,
- the activation/configuration of these physical resources to perform the task required by the context.

Context only refers to objects as an abstract model of what kind of objects have to be taken into account in a certain context, whereas an active context refers to physical resources that have been identified during the activation process. Active contexts are of dynamic nature reflecting the current environment an individual resides in.

The activation and deactivation of contexts is one task of I-centric Services. To activate a context the I-centric Service performs the activities described above. In addition, the I-centric communications system has to manage concurrent access to objects and conflicts caused by contrary wishes, expressed by individual(s).

A context is active when it is adapted to a certain environment at a certain moment in time. It defines the relationships and causalities of an individual to a particular number of physical resources at certain a moment in time, in a certain environment.

Acting in a context means to use only services that are provided by objects, which are part of that very context. Starting to interact with objects that are not part of an active context causes the activation of another context. That means, on one hand individuals are allowed to act in several contexts in parallel, and on the other hand, the I-centric communications system must handle conflicts that might occur due to contrary causalities defined in the different contexts.

To handle each individual communication space and associated contexts, a general model of domain information and relationships to objects and physical resources is needed. This model must be flexible to be enhanced due to the introduction of new locations, devices, etc.

2.3.2 Preferences and Ambient Information

Individuals have different preferences in different situations. With preferences, individuals express their choices of services characteristics in certain contexts. Therefore, preferences provide a powerful mechanism to influence the behavior of I-centric Services by giving them explicit instructions.

Preferences are conditional choices of service characteristics of an object depending on context and ambient information. Preferences are applied to objects during the activation of a context.

I-centric Services evaluate preferences to adapt their behavior to what is 'really wanted' by an individual in a certain environment at certain moment in time. Therefore, preferences have to be either gathered from individuals interactively or automated by monitoring, and they have to be expressed in a machine computable form.

The description of preferences, which can be processed automatically, is another challenging task. Preferences can capture many aspects like mood, interests, live stage etc. that are even hard to describe in words. Furthermore, the kind of preferences that are relevant to different individuals may differ completely. A model for describing preferences must be as generic as possible to avoid restrictions that might prevent the expression of a certain preference. On the other hand, the model has to provide some structuring or categories to allow the assignment of preferences to a certain I-centric Service.

In general, ambient information is information that can be collected, gathered, or sensed from the environment. Ambient information comprises temporal and spatial characteristics like any user input, temperature, noise

level, light intensity, and presence of other people just to give a few examples. Ambient information is sensed by sensing facilities, like motion detectors or microphones, and transmitted through sensor networks. Ambient information may also include geographical information, environmental information, and life conditions.

Ambient information is information that can be collected, gathered, or sensed from the physical environment using the objects of the individual communication space of a certain individual.

A semantic model is needed to describe preferences and ambient information. Such kind of model incorporates knowledge representation to qualify available information and ontology languages to relate syntax and semantic to each other. The focus for I-centric communications here is to define a harmonized semantic model that includes human aspects as well as the process to gather, store, evaluate, and exchange preferences as well as ambient information.

2.3.3 I-centric Service

I-centric Services define, manage, and (de)activate contexts in an individual communication space taking the preferences of individuals and ambient information into account. They support an individual (I-centric), adaptive, personalized, and ambient-aware, way to interact with objects in individual communication spaces.

I-centric Services need ambient information in order to adapt to the environment. Temporal and spatial characteristics are only two examples of information, which may affect the service behavior. Note, that a certain environment can restrict the functionality requested in a certain context. Interacting in a TV context' while driving a car may reduce the available functionality to 'record the movie for later viewing' or to listen just to the audio part.

I-centric Services activate contexts by choosing the equipment to be controlled, their quality of service to be finally connected via heterogeneous networks to create an I-virtual private network.

The process of choosing and controlling the equipment of the physical environment is supervised by the service logic of I-centric Services. The service logic controls the activation of contexts by combining multiple objects dynamically. It parameterizes objects by defining what, when, and how one or more objects behave in a given condition. The service logic decides based on profiles and on the status of the objects how those objects should behave in a certain situation. This enables sensitive services that adapt to the environment dynamically.

Nowadays, service logic is in most cases 'hard-coded'. Once implemented, it cannot be changed afterwards. The basic idea of I-centric

communications is to provide individuals with their own services that might change over time.

The process of creating or modifying I-centric Services has to be accompanied by ontology definitions that describe what services an object is providing. Interactive applications are envisaged that allow individuals to assemble their service by simple ‘drag and drop’ mechanism. Like a LEGO™ toolbox, the individual should be able to create and to deploy its I-centric Services.

2.4 Reference Model for I-centric Communications

Figure 2 shows the reference model for I-centric communications. It follows a top-down approach starting with the introduction of individual communication spaces, related contexts, and objects. In general, the topmost layer recalls the I-centric vision that human beings interact with objects of their communication in a certain context. It is common understanding that I-centric Services have at least to support three different features, namely ambient-awareness, personalization, and adaptability. To emphasize that these features are needed for I-centric communications they have been assigned to the individual communication space.

The service platform for I-centric communications is responsible for shaping the communication system, based on individual communication spaces, contexts, preferences, and ambient information. Preferences are provided by the personalization feature, whereas ambient information is provided by ambient-awareness feature.

The IP based communication subsystem provides the linkage between different objects in the communication spaces. These links have to be maintained and managed even when they are subject to change because of roaming between different network topologies or access networks. IP communication is seen as the common denominator to harmonize heterogeneous network infrastructures.

The Wired or wireless Networks layer implements all aspects of the physical connection(s) between different objects. Due to the hierarchical structure of the reference model, a connection in the IP based communication subsystem might use multiple connections in underlying network.

The main features of I-centric communications (ambient-awareness, personalization, and adaptability) affect all layers. Therefore, supporting functions have to be provided as a vertical solution. The reference model introduces the concept of Generic Service Elements that implements common functionalities on all layers. Generic Service Element can be seen

as a toolbox from which complex services can be assembled and executed dynamically.

Figure 2: Reference Model for I-centric Communications

Accompanying to all these technical issues, the Business Model for I-centric communication identifies the relationships and information flows between all active roles within an I-centric system.

2.4.1. Business Model

The borders between traditional roles and administrative domains: network provider, content provider, service provider, and retailer are blurring. An individual may become service provider, or content provider, or retailer. Additionally, roles may change dependant on context, which implies a very flexible business model.

The business model for I-centric communication has to cover:

- roles, relationships, and reference points
- business topologies
- service lifecycle (creation, deployment, management, and billing)
- benefits for parties involved in the market value network

The first objective of a business model for I-centric communication is a model for describing relationships between involved parties in a global business community. Based on these relationships, roles and reference points

are defined. This allows the participation of each business partner on a global business on one side and provides the freedom in development and integration on the other side. Reference points provide standardized points of contact and information exchange between business partners.

2.4.2 Personalization

Information and services must become increasingly tailored to individual preferences to make the usage of services easier and the perception of the individual communication space richer.

Objects available in an individual communications space have to adapt to the preferences of individuals. Personalization models each individual in the I-centric Service platform by managing its preferences and providing these preferences to I-centric Services.

To reach this goal, personalization federates profile information (containing preferences). Personalization incorporates dynamic behavior to enrich stored and federated information to enable pro-active I-centric Services. This leads to an overall profiling infrastructure managing the individual preferences.

The main research issues behind personalization are:

- how to gain preferences from individuals (interactively or automated)
- how to store preferences in profiles (profile format & categories),
- secure privacy sensitive parts of profiles.

2.4.3 Ambient-Awareness

In I-centric systems, services are tailored to contexts of the individual communication spaces. The services automatically adapt themselves to changes in the environment of nomadic individuals.

The federation of ambient information from various sources, according to individual's mobility and roaming is an integral part of ambient-awareness. Intelligent inference systems for missing information are needed in order to incorporate as much information as possible to provide an automatic, ambient-aware environment to the individual.

Ambient-awareness is the functionality provided by an I-centric system to sense and exchange information about the current environment, an individual is in at a certain moment in time.

Sensors networks will play a major role in providing ambient information. Sensor technologies will be embedded in mobile equipment, communication networks, living and working environments to sense who the user is, where he is, what he is doing, what the environmental conditions are, to provide this ambient information to I-centric Services.

2.4.4 Adaptability

Adaptability is mainly based on information provided by personalization and ambient-awareness. It provides the functionality to adapt I-centric Services to personal preferences and environmental conditions. Therefore, adaptability can be seen as a function that activates a context based on whatever information is provided by ambient-awareness and personalization.

In general, I-centric adaptability translates the wishes of individuals, which are usually inaccurate, incomplete and sometimes even contradictory, into a set of rules precise enough for processing to be automated with sufficient reliability. It has implications in the structure of the services to allow adaptability and is the engine, which activates a context at a certain moment in time in a certain environment.

Typical situations when adaptation takes place include a substantial change in characteristics of connectivity, entering into a new service domain, or changing terminal device in service session.

By technical means, adaptability requires the adaptation of media, content, and service behavior. During the last years, a variety of concepts for adaptation has been developed [Pfe99]:

- communication streams can be altered during transmission (e.g. bit rate adaptation),
- media types can be changed (e.g. text-to-speech conversion),
- type of presentation can be adapted (e.g. downscaling an image),
- altering the content of a message (e.g. adding or stripping off information), or
- modifying the service behavior (e.g. by customer service control).

Adaptability cannot be only reactive. When the battery of a mobile device dies or the connectivity breaks, many actions become impossible. Therefore, adaptation must also be proactive, which in turn requires predictability of the near future.

2.4.5 Service Platform for I-centric Communications

A Service Platform for I-centric communications is responsible for shaping the communication system, based on individual communication spaces, contexts, preferences, and ambient information. Finally, it (de)activates objects (advised by I-centric Service), identifies causalities between them based on sensed environmental data, controls the services offered by these objects, and converts data structures and operations for interworking between services. The equipment is configured dynamically, its state is profiled, distributed objects are controlled, service creation and deployment are supervised, and the interworking among domains is enabled by the platform.

To fulfill the functionalities requested by I-centric communications, I-centric Service platforms have requirements on the underlying communication subsystem. This is caused mainly by the empowerment of any individual to act as a service provider or network provider in a paradigm shift from a provider centric paradigm to a decentralized I-centric paradigm.

On the other hand, the requirements are based on information that has to be provided by lower layers to the service platform. Traditional platform approaches (e.g. object-oriented middleware platforms) try to hide as much as possible technical parameter between the different layers. I-centric Services have to be provided with ambient information.

However, the paradigm shift addressed here does not only concern the individual as a provider of network related services. A service platform allowing global mobility and transparent access to any kind of service over a common IP platform is the basis for allowing everyone to provide a wide range of services.

2.4.6 Generic Service Elements

I-centric communications systems have to cope with issues like numerous service providers, always-connected individuals, automatic service adaptation, and ambient-awareness. Aspects like dynamic service discovery and service provisioning in (for individuals and services) unknown environments and personalized services usage requires new mechanisms to support I-centric communications systems.

To simplify the definition and realization of I-centric Services and applications, a set of reusable software components support functionalities common for different services and applications. These components are called Generic Service Elements to emphasis their general applicability for all kind of services.

A GSE is a functional software component that can be used by other GSEs, services, or applications and it is hosted by the I-centric Service platform. GSEs provide functionalities common to different services and applications to ease and shorten their development process.

Because I-centric Services should work under changing environmental conditions, serving changing individual preferences, the most promising candidates for common functions are: Service Discovery, Service Management, Service Deployment, Service Composition, Service Logic, Service Control, and Environment Monitoring.

Consequently, well-defined collections of interface specifications designed for certain business domains are needed. Such interfaces must provide framework functionality, like hot plugging of services, dynamic (re-)binding, service mobility, AAA-services, support for automated SLA negotiation, contracting, and so on.

3. SUMMARY

This chapter has introduced the vision and the reference model for I-centric communications. A service architecture compliant to the Reference Model for I-centric communications is needed, to implement I-centric communications systems. The Service Architecture has to define building blocks and their interworking to provide the functionality requested by the reference model.

The service scenarios, expected to become possible with I-centric communications, require the design of interaction mechanisms for distributed objects. Furthermore, object and service discovery mechanisms, and object repositories are needed to enable intelligent service brokerage. Service and object ontologies facilitate these discovery and brokerage mechanisms.

Profiling, decision making, and intelligent device control has to be embedded in the business logic of I-centric Services. A user/context model for I-centric communications is wanted to feed the business logic of personalized, ambient-aware, and adaptive services.

Service Composition and Service Bundling are the elements to combine the services provided by the objects of individual communication spaces. Due to the variety of objects and services to be combined in I-centric Service, a Service creation environment is needed that suits the requirements of individual users.

To come up with a coherent service architecture for I-centric communications systems these aspects have to be integrated into a single framework. This work is currently carried out by Wireless World Research Forum WG2.

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