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"The WSI Reference Model"

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1 *Int* *Internal circulation within project (and Commission project Officer if requested)*
Res *Restricted circulation list (specify in footnote) and Commission PO only*
IST *Circulation within IST Programme participants*
FP5 *Circulation within Framework Programme participants*
Pub *Public document*

2 (R)eport, (P)rototype, (D)emonstrator, (S)pecification, (T)ool, (O)ther

3 V0.x=Draft, V1.x=Final. (D1=First Draft, R1=Technically Revised, D2=Final Draft, R2=Final Revised, F=Final)

Abstract:

The Reference model developed covers all aspects of the wireless world from business models and user issues down to radio interfaces. The reference model describes the grand building blocks of the Wireless World and how they interact at reference points. The reference model accommodates user scenarios and different views. The combined definition of business models and reference points enable the early definition of roles and business relationships as well as assumptions on business topology and market value chains and value networks.

Revision History

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V0	2002/10/4	Ralf Pabst	Initial version
V0.1	2002/10/29	Ralf Pabst	First revised draft with input from Nokia, Oulu, Fokus, UniS and Aachen
V0.2	2002/11/11	Stefan Arbanowski	D10 material removed Ref. Model desc. enhanced Section Structure reworked
V0.3	2002/11/28	Stefan Arbanowski	Added Input from: Ericsson, Surrey, Aachen, Fokus
V0.4	2002/12/06	Stefan Arbanowski	input added from Surrey some minor typos version # in revision history corrected
V0.5	2002/12/10	Stefan Arbanowski	Input added from NOKIA
V0.6	2002/12/17	Stefan Arbanowski	Comments form Ericsson included Input added from Aachen, Oulu
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V0.8	2002/12/20	Stefan Arbanowski	Final comments

1 Executive Summary

The WSI reference model describes the Wireless World as a set of concentric spheres inhabited by networked Communication Elements (CEs). CEs are the generic representation of devices and nodes in the Wireless World as visualized in Figure 4-1. The functions incorporated in a CE are provided by different building blocks, briefly explained below.

The “Cyberworld” building block hosts all application-specific functionality. It relies on a generic service infrastructure provided by the “Open Service Platform” and exploits it to implement these applications and services. It will have to possess means to generically describe and explain their characteristics and demands to ensure that the underlying infrastructure is being used efficiently and to the user’s satisfaction.

The “Open Service Platforms” building block is responsible for providing a flexible and generic service infrastructure to the CyberWorld to facilitate the creation of new services according to user’s and operator’s needs. The restrictions imposed on the creator of services have to be reduced to a minimum.

The “Interconnectivity” building block can also be referred to as the Networking part of the Wireless World reference model. The functions located there take care of linking together CEs from different spheres and maintain and manage these links even when they are subject to change of network topologies or access networks.

The “Access” block implements all aspects of the physical connection(s) between different CEs. These may be either radio or other types of connections. Due to the hierarchical structure of the reference model, a connection in higher spheres could use multiple connections in underlying spheres, relying on services provided by the “Interconnectivity” block.

Reference points have been defined between the building blocks of a Communication Element and among different Communication Elements.

In addition to the static view of the model outlined above, the document also contains a first attempt to describe the dynamic behaviour of the reference model in the annex.

The work on the reference model for the Wireless World is well advanced and based on a good understanding of the requirements and of the working of future communication systems. There is, however, research work remaining to be undertaken that exceeds the boundaries of this limited study. Some issues to be addressed by future work in WWRF or projects proposed in WWRI include:

- A formal description of the semantics of the Reference Points
- A methodology to define communications via the Reference Points
- A functional distribution and allocation to building blocks
- Dynamic representations of major transactions
- More details of possible business models.

2 Table of Contents

3 Introduction and overview

The objective of WP2 was to develop the basis for the definition of concepts for future wireless systems. The “Think Tank” in Project Year 1 developed first ideas and opened up the research community through the establishment of the “Wireless World Research Forum (WWRF)” in WSI’s second project year. In 2002, the WP2 focussed its work on developing fundamentals required to enable timely research to be undertaken and to be able to effectively synchronise research between academia and industry.

Following the Book of Visions [BoV] to have user centred services in the wireless world an open list of **Service Characteristics** has been defined to be reflected by the WSI Reference Model. The list comprises so far: **Ambient Awareness** as basis for all kind of contextual services, **Personalization** to reflect user needs and preferences, **Adaptability** to react to the dynamic nature of future communication environments, **Ubiquity** to emphasize the availability of services despite of underlying network and hardware infrastructure, and **Consistency** to address issues like privacy, trust and security from a very user perspective. These Service Characteristics will be further used to define what is called **User Values.** They correspond to abstract user models and define the basis for easy-to-use, user-centred services.

4 The WSI reference model

The **Reference model** developed covers all aspects of the wireless world from business models and user issues down to radio interfaces. The reference model describes the grand building blocks of the Wireless World and how they interact at reference points. The reference model accommodates user scenarios and different views. The combined definition of business models and reference points enable the early definition of roles and business relationships as well as assumptions on business topology and market value chains and value networks.

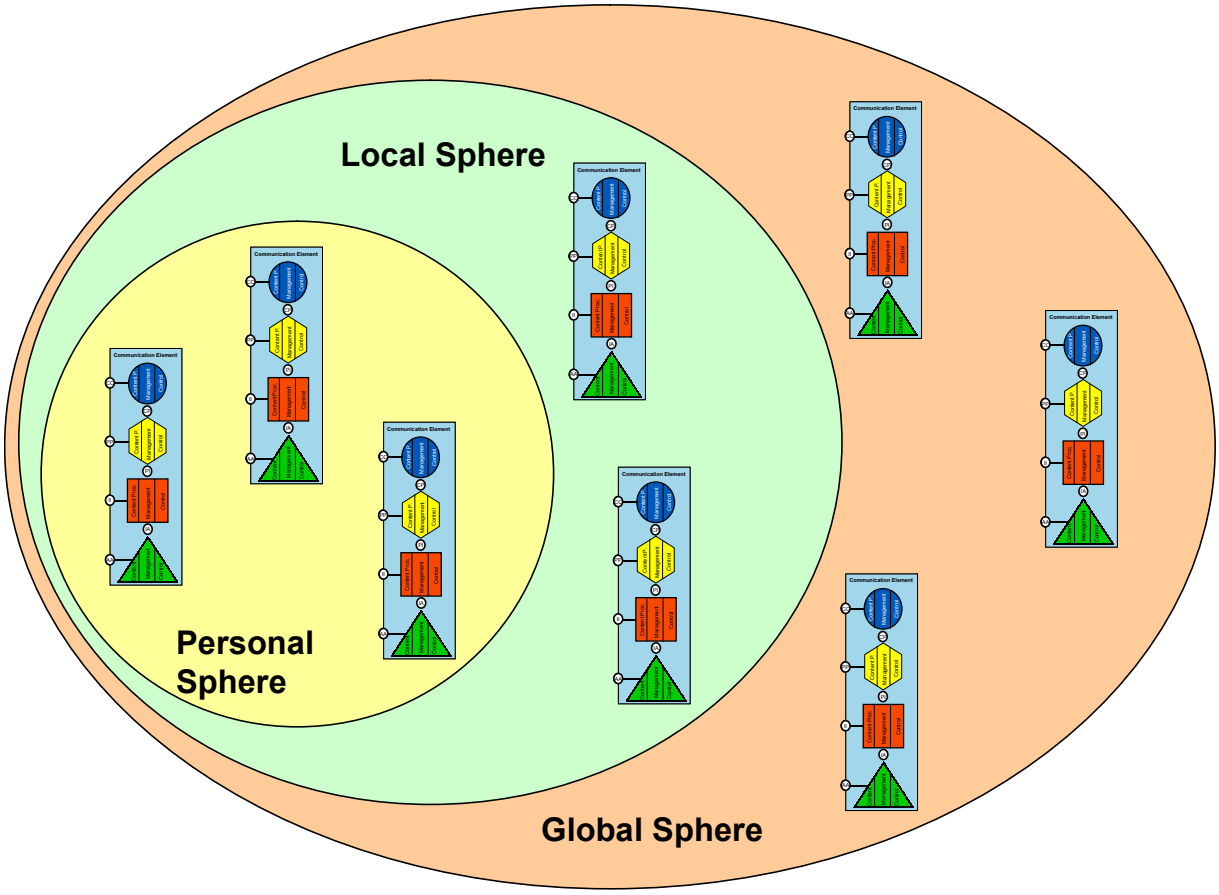


Figure 4-1: Example structure of the WSI reference model

Following the sphere model, which was developed by the "Think Tank", the reference model identifies the building blocks of the wireless future. The main achievement is the definition of a "**Communication Element**" that acts as a communication entity in the different spheres. The Wireless World will consist of a huge number of these Communication Elements. Therefore, the communication elements will have a generalised structure. Depending on their current communication context, they can be logically placed in different spheres (global, local and personal sphere, for example). The different spheres reflect the vicinity of building blocks in respect to a user communicating in the wireless world. So in the example, the Local Sphere can be seen as some kind of Body Area Network, the Local Sphere serves local networking infrastructure, and the Global Sphere is responsible for global connectivity.

4.1 The Communication Element of the Wireless World

A communication element can be understood as the representation of a certain device or node in the network as visualized in Figure 4-2. The functionalities integrated in the communication element are provided by different building blocks. The assumption is that the reference model should separate *Content processing*, *Control*, and *Management* functions into the own end-to-end planes and subsystems. The architecture should not allow mixture of these three functions in specification. Therefore, a subdivision common to all building blocks of the communication element has been defined.

Content Processing Functions are related to the processing, transforming, adapting and end-to-end delivery of application data.

Management Functions include those functions responsible for both horizontal and vertical management. The horizontal management takes care of functions inside a certain block of

the communication element (block or layer management), while vertical management (or plane management) coordinates the cooperation between the building blocks.

Control Functions handle all signalling which is associated to the Content Processing Functions. They take care of negotiation and agreement of QoS parameters and need to span all building blocks in order to provide true end-to-end QoS for end users.

Reference Points within a Communication Element:
- CP – Cyberworld/Platform
- PI – Platform/Interconnectivity
- IA – Interconnectivity/Access

Reference Points across Communication Elements:
- CC – Cyberworld/Cyberworld
- PP – Platform/Platform
- II – Interconnectivity/Interconnectivity
- AA – Access/Access

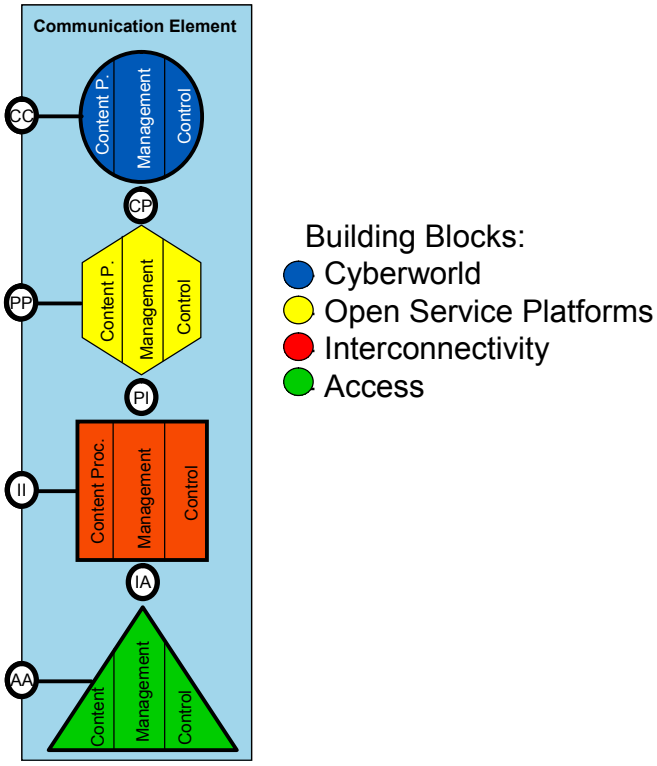


Figure 4-2: Building Blocks of Wireless World Communication Elements

A communication element will consist of 4 different Building Blocks (see Figure 4-2):

- **Cyberworld** hosts all application-specific functionality. It relies on a generic service infrastructure provided by the "Open Service Platform" and exploits it to implement applications and services. It will have to possess means to generically describe and explain their characteristics and demands to ensure that the underlying infrastructure is being used efficiently and to the user's satisfaction.

- **Open Service Platform** is responsible for providing a flexible and generic service infrastructure to the CyberWorld, in order to facilitate the creation of new services according to user's and operator's needs. The restrictions imposed on the creator of services have to be reduced to a minimum by providing reusable generic service elements.

- **Interconnectivity** can also be referred to as the Networking part of the Wireless World reference model. The functions located there take care of logically linking communication elements from different spheres together and maintain and manage these links even when they are subject to change of network topologies or access networks.

- **Access** implements all aspects of the physical connection(s) between different CEs. These may be either radio or other types of connections. Due to the hierarchical structure of the reference model, a connection in higher spheres could use multiple connections in underlying spheres, relying on services provided by the "Interconnectivity" block.

4.1.1 CyberWorld

4.1.1.1 Rationale:

Today, the World Wide Web is chaotic. So much unstructured data exists that most people have hard time finding information relevant to the situation at hand. This problem is particularly acute for mobile users, who increasingly want to access web services while on the move. At the same time media are increasingly going digital, and more and more material is being made available every day. Digital imaging, desktop video, loop-based music software and web diaries are examples where both professionals and amateurs are producing content with computer-based tools.

The current non-mobile web offers little help for mobile contexts. The mobile user faces another kind of chaos in the form of information overload. As positioning systems and short-range communications are becoming commonplace, mobile terminals will be flooded with increasing amounts of on-the-spot information. Despite the added local aspect, there will be abundant data available, but relevant information will still be hard to find.

The aim of the wireless world will be to make the relevant information available to people in their daily lives. Considering the numerous possible contexts (not just location), it becomes evident that common descriptions for context information are needed. Similarly, mechanisms for managing and handling dynamic context information within the semantic web and devices on the move are also required.

4.1.1.2 Definition

The word “cyber” alone relates itself to science and communication, a world of advanced technology beyond human mental capacity. Cyberworld can be defined as a new world, a parallel world created and sustained by the world’s computers, wearable communication terminals and device-less interactions. In the Cyberworld we can stay in touch with our agents, knowledge bases, communities, services and transactions.

4.1.1.3 The Cyberworld in the wireless World

The Cyberworld in the wireless world deals with application functionality and the interaction with the environment. It can be classified by five components:

- Presence, Identity, Interaction, Application, and Cyberhost.

Each of the components is then refined further to identify the predominant features and/or subcomponents. The Cyberworld structure and reference model are demonstrated in Figure 4-1 and Figure 4-3 respectively.

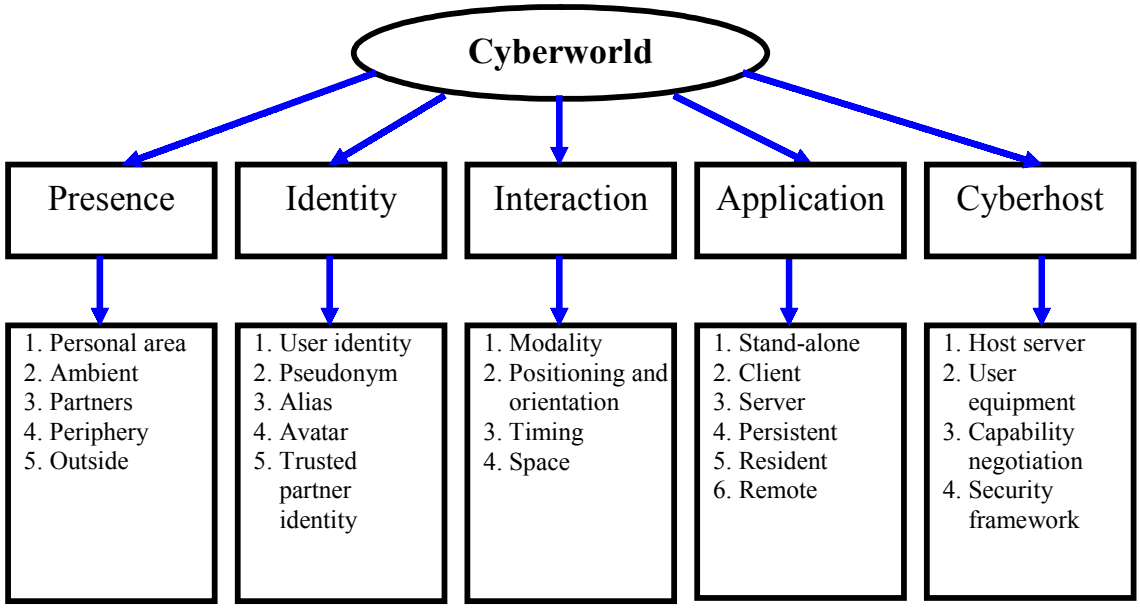


Figure 4-3: Cyberworld Structure for Wireless World

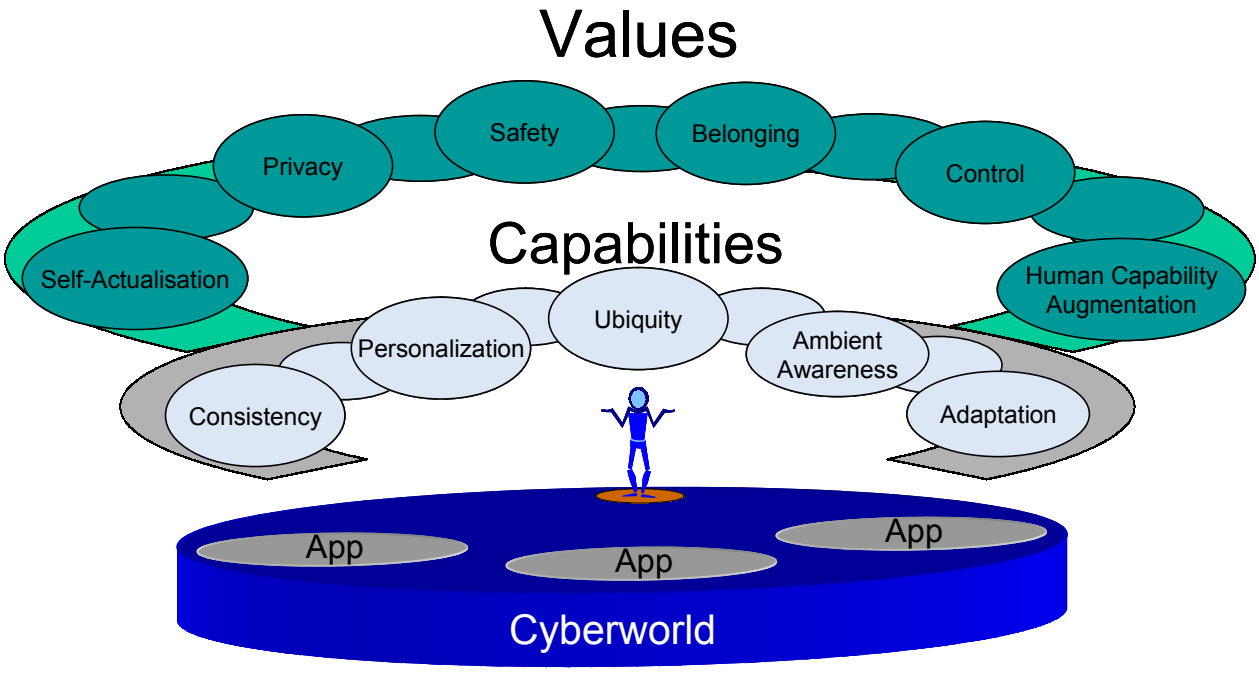


Figure 4-4 Cyberworld Reference Model for Wireless World

Value

The value function deals with user – centred mobile service and application development. All the mobile services are driven by user values. Research in this area includes studies to show how the key characteristics of mobile users form the rationale for developing services that are wanted and easily approved by the consumers. Mobile users can be modelled relying on the analysis of cognitive cultural schemes, emphasizing transfer, social group

factors and motivation. Quality Function Deployment (QFD) [7,8,9] is a powerful method to collect, prioritize and balance user needs and effectively build them into the mobile services.

Capability

Mobile service application capabilities reflect the internal and external mobile service requirements and characteristics. Mobile service application capabilities consist of the following six functions: Consistency, Personalization, Ubiquity, Natural interaction, Ambient Awareness and Adaptation. These application capabilities represent implementation requirements and characteristics of mobile service applications. They address the values of the service system or network beyond the user needs and act as a linkage between user values and mobile service development.

Presence

Presence describes the sphere of information presentation to the user in the wireless world. It is classified as five zones: Personal area, Ambient, Partners, Periphery and Outside. Personal area is the zone containing all personal information and tools. Ambient is about the zone next to the personal area. Partners are those potential communication users and machines. Periphery is the zone of awareness of the user and outside is everything else that the user is not aware of.

Identity

Mobile services and applications should be executed by a secure framework. The function of Identity is to provide a secure means to dynamically interact between users and partners, in a manner of the content of the requested service being tailored for particular needs of the user and the partner. The Identity function includes user identity, trusted partner identity, avatar, pseudonym and alias that are used to fulfil identity and secure requirements in mobile service execution.

Interaction

By its very nature Interaction contains the issues of Modality, Positioning and Orientation, Timing and Space. Modality is about interaction classification, which could be defined according to different criteria like level of interaction and amount of interaction. Positioning and Orientation are key functions for successful Augmented Reality (AR) and Virtual Reality (VR) applications. Timing is about the time requirements in mobile service system synchronization and execution and it also used to provide the logging function. In mobile services and applications we need to consider user and partner location, positioning and orientation, thus the Space issue is one of the important concerns in wireless world.

Application

The mobile service application is categorized as the following six types: Stand-alone, Client, Server, Persistent, Resident and Remote. Various existing mobile applications can be fit into this category. Recent advances in computer and telecommunications have enabled a number of new and exciting applications.

Cyberhost

The Cyberhost provides a standardized local execution environment for mobile services and application. A capability negotiation and security framework are the most important generic Cyberhost requirements. Cyberhost supports an ability to negotiate capabilities with the other Cyberhost servers and underlying service platforms and it also offers a security framework for the execution of applications.

4.1.2 Open Service Platform

4.1.2.1 Rationale

The introduction of new services, and convergence between networks, will create a highly diversified value chain with new roles and key players (e.g. content providers, application providers, portal providers, mobile virtual network operators, etc.) in the area of network and service provisioning. Flexibility, in terms of supported business models, will reduce the time to market for new services. Standard open interfaces will foster the deployment of such service delivery chains.

Despite the underlying network complexity and heterogeneity, the service delivery will be, from the user perspective, simple, uniform and seamless. Advanced techniques for delivering mobility, service continuity, end-to-end security and QoS will be required. The inherently variable quality of radio links may have to be compensated through mechanisms such as content or bandwidth adaptation.

The introduction, provision and management of numerous, probably highly complex services will be associated with factorization of key information, such as user knowledge and context awareness. A set of advanced key features, such as profiling, contextual information delivery, filtering, billing, user privacy guarantee, etc. shall be implemented in the core network for service facilitation.

4.1.2.2 Definition

The “Open Service Platform” is responsible for providing a flexible and generic service infrastructure to the CyberWorld, in order to facilitate the creation of new services according to user’s and operator’s needs. The restrictions imposed on the creator of services have to be reduced to a minimum possible.

4.1.2.3 Open Service Platforms of the Wireless World

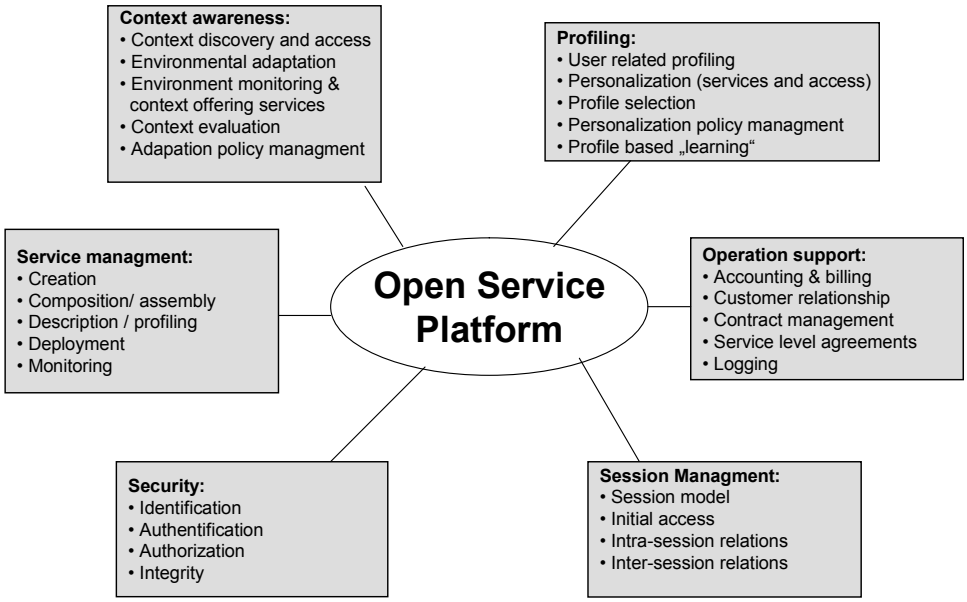


Figure 4-5: Open Service Platform structure

4.1.2.3.1 Context Awareness

Context handling

In a generic model functionality for the management and evaluation of adaptation policies and the performance of environmental adaptation is required. Thus user related profiling, service personalization, and content adaptation can be considered as special cases of environmental adaptation.

Location Awareness

Location awareness function shall provide the positioning data of a user. It can be provided automatically or the user has to prompt his/her position to the system.

Presence Awareness

Presence Awareness function shall provide the state of user presence. It can happen also either automatically with help of profiling function or the user can active/deactivate his/her presence him/herself.

4.1.2.3.2 Profiling

User Profiling

This function shall provide the management of user preferences. Users shall be able to specify their preferences for service usage, i.e. how a service should behave in a certain situation. This can depend on time constraints, location, terminal, presence and availability, etc.

Profile Management

According the profile model a user may define different user profiles for different situations. The selection of the proper user profile will be performed by Profile Manager.

Service Personalization

In order to appear personalized, services have to provide parameters that influence the service behaviours according to the user wishes. These parameters should be collected as a set of service preferences which are managed by the user profile function. On service usage the service must obtain and consider these service preferences. The user profiling function is responsible to determine which concrete set of preferences should be used in a specific situation.

4.1.2.3.3 Adaptation

In order to be able to provide services independent of any technologies the Adaptation functionality is needed. This functionality allow the Application Assembler to develop or assemble its Application without thinking about which capabilities are available on existing infrastructure (e.g. network and end system) and how Application GUIs, Interactions or contents have to be presented on the users end system. For this purpose the Adaptation Component needs the necessary context information. These are information like user preferences (user profiles), general user data, network capabilities, device capabilities and correspondent preferences.

4.1.2.3.4 Security – Identification/Authentication

In order to provide personalization users have to be identified. Different identification methods should be supported. For example if a user accesses the service by telephone, a telephone number has to be matched to the user identity. In order to provide user identification a person has to be registered. The system has to support also user authentication in order to provide reliable access control. Different authentication methods have to be supported, for example in case of access by a telephone a user id in connection with pin number serves as user authentication.

4.1.2.3.5 Session Management

Future systems have to provide multi-modal service usage. That means that a user can access a service through several devices simultaneously and communicate with the service which remains it's state. After user identification/authentication the service goes to the appropriate state of the already opened session and adapts to the terminal used currently.

4.1.2.3.6 Operation Support

Accounting / Subscription

User accounting shall support different business models. Subscription of services shall be also provided in a flexible manner.

Service / Application Management

This function is responsible for service installation, service configuration and customization, service profiling and service creation. The service installation comprises all functionalities which enables the provider to deploy new application flexibly. This is one of the most important functionalities of a future service platforms, because having a powerful and flexible concept for service installation allows the provider to integrate (deploy) a wide range of different application types (e.g. the already existing legacy applications or the application which will based on the future technology).

Customer and Contract Management

This function is responsible for management of customers and their contracts. According the requirements a customer should be able to define different users or user groups and give them different level of permissions for usage of subscribed services. Furthermore the Customer should be able to assign to different users the same service with different capabilities.

4.1.3 Interconnectivity

4.1.3.1 Rationale

The Wireless World will offer seamless integration of all means of access and scalable support for the user's communication and information needs. A unified control space will make these resources usable and convenient. The Interconnectivity block will take full account of the attached terminal network's (PANs or BANs) capabilities and support them in an ad-hoc fashion. Similarly, this block will have to generically support and assist the requirements of the Open Service Platform. Its functions are of particular interest in a mobile wireless world where the user is constantly changing access, location and context and network topology might change as well. Major new challenges, evolved from today's emerging all-IP paradigm, are raised by moving networks within networks and by reconfigurable co-operative network infrastructures.

Moving Networks within Networks: In the future, systems will extend into the user domain, featuring both personal area networks and privately owned and operated access networks. This will lead to private networks which move with respect to wider area public networks and which will need to connect in a simple, secure and rich manner to public short range and wide area networks. The currently emerging body area networks (BAN), personal area networks (PAN), home networks, car networks, and public hotspots, are precursors of this development and will need the support of seamless access and convenience for the user.

Reconfigurable, co-operative network infrastructure: In the near future, a more diversified value chain with new roles and key players (e.g. content provider, application provider, portal provider, mobile virtual network operator, etc.) in the area of network and service provision will require a more flexible, reconfigurable and co-operative network. Flexibility will be needed in terms of business model types supported by the networks, reconfigurability of the technologies used and co-operation between functions offered to edge networks.

The “Interconnectivity” block can also be referred to as the Networking part of the Wireless World reference model. The functions located there take care of logically linking together CEs from different spheres and maintain and manage these links even when they are subject to change of network topologies or access networks.

4.1.3.2 Definition

Interconnectivity describes the basic functionality to be provided by both wired and wirelessly networked infrastructures. Interconnectivity provides the communication means for higher layer user services and applications by using the access and transmission capabilities of heterogeneous network environments.

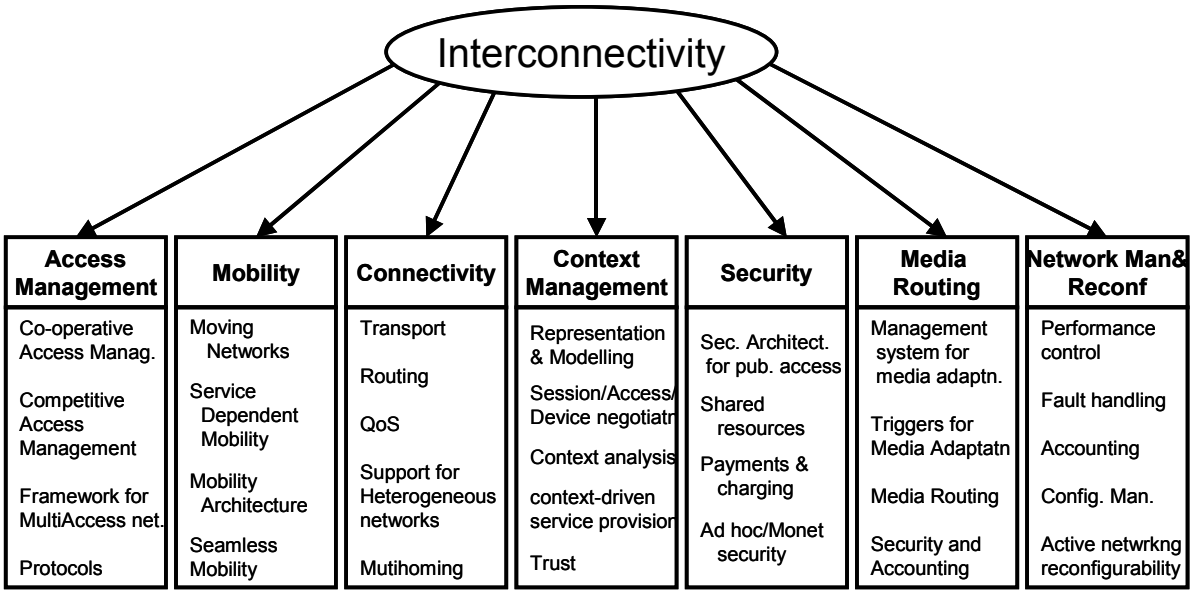


Figure 4-6: Wireless World- Interconnectivity – enabling technologies

4.1.3.3 Interconnectivity in the Wireless World

The Wireless World is expected to offer seamless integration of all means of access and scalable support for the user's communication and information needs. A unified control and management space will make these resources usable and easily applicable.

The interconnectivity block within the Wireless World Reference Model will provide the mechanisms that glue the connected and associated access networks into an, albeit

heterogeneous, yet integrated network environment. The objective is to provide transport mechanisms capable to react to dynamic changes in transmission rates and speeds caused by possible losses due to mobility of the wireless user equipment or moving networks and to provide coherent support for services and applications. This includes communications throughout the network/networks from source to destination and raises the necessity for development of advanced congestion control mechanisms as well as novel routing protocols and algorithms that facilitate addressing, routing and roaming for and within connected ad hoc networks and the capability to use legacy wireless access technologies as well as to introduce new radio access schemes.

4.1.3.3.1 Access Management

The vision of the wireless world foresees the co-operation of a larger number of access technologies to provide ubiquitous access to services in the Cyberworld. The access is to be guaranteed despite of the current location and mobility pattern of the user. It is further expected that the access technologies, which are tailored to certain environments and applications, will break up the boundaries currently existing between each other to allow for an optimised selection of access technologies depending on mobility patterns and transmission demands. This is supposed to ensure an efficient fulfilment of the requirements on ubiquitous and mobility independent access to services. The implication of this vision is that the usage pattern and the need for certain access technologies will determine the traffic load that has to be handled by a single type of access network.

Co-operative Access Management

It is thus important that resources can be shared between the different access technologies, as static assignments of those will impose restrictions on the access network selection. Common resources need to be assigned according to the utilization of certain access systems.

An access management framework needs ad-hoc communication to be present to allow the dynamic assignment of resources to the access systems making best use of them. The traffic volume and traffic types requested by the end-user should determine the utilization of the different access technologies and resources should be assigned accordingly.

The dynamic resource assignment scheme described above assumes that the access technologies sharing the resources are under control of a single operator or at least co-operate under a certain frame agreement, which has been agreed beforehand.

Competitive Access Management

The co-operative access management described above requires that the access systems sharing resources are tightly coupled. This will probably only be realistic if they are under a single operator’s control

In any other cases the access technologies are in a competitive relation to each other. Resource sharing would in these cases only be possible if in addition to a resource exchange framework, the financial relation between resource owner and resource user is supported by appropriate charging functions and routines for financial interactions.

While co-operative access management aims at the selection of the most appropriate and resource efficient radio access for the different user data flows, the competitive access management includes additionally business considerations, which might lead to different selections of access networks than purely efficiency-focused deliberations would motivate. Consequently, an access management framework needs to allow any business model and protect the different players by appropriate means.

4.1.3.3.2 Mobility and Moving Networks

Existing mobility management schemes have been developed in an isolated manner. Mobility management schemes located on link level are optimized for certain access technologies and function only within homogeneous networks. Mobility across networks is typically realized on higher protocol layers. Most popular is mobile IP and its derivates such as hierarchical mobile IP (HMIP). The drawback of this separation is that either the application of the mobility management scheme is restricted to certain network technologies or link layer specifics are not taken into account, which results into inefficient solutions.

For realizing the vision of the wireless work it becomes essential to have a well co-operating mobility management structure combining the different mobility management schemes operating in hierarchically neighbouring or stacked networks levels.

The issues to be considered are context transfer, moving networks and seamless handover procedures based on L2 triggers and higher layer information. The system must support terminal mobility, session mobility and inter-domain mobility with the interworking between micro- and macro mobility solutions.

Moving Networks

The mobility management scheme of the wireless world has to cover mobility of groups as a whole as well as mobility of members within a group. The groups to be considered are both of a more physical nature, e.g. clusters of devices forming a group of geographical neighbours, as well as more logical clusters such as multicast groups. Such clusters forming moving networks can build recursive structures, i.e. the mobility management scheme has to efficiently support moving networks within moving networks.

Service Dependent Mobility

The mobility management scheme, which is to be deployed for realizing the vision of the wireless world, has not only to consider the geographical location of devices but take into account flow characteristics, mobility patterns and resource availability as well.

4.1.3.3.3 Connectivity

Connectivity within the interconnectivity layer of the WSI reference model provides the means to design an environment within the current and future heterogeneous networks, which ensures end-to-end QoS provision for user services delivered across a heterogeneous networking environment. This encompasses research into multiple areas of networking including transport, routing, QoS protocols as well as multi-homing.

QoS

The most stringent problems for QoS provision is the controlled setting of some basic parameters including: bandwidth, delay, jitter, and error rates. Availability and service disruptions will then be the result of a combination of different design and implementation issues including: scalable network design, network dimensioning, network flexibility, and service provisioning, etc.. Focus of targeted research work needs to tackle issues like scalability of the control layer and flexibility (with regard to) changing physical environments and requires the availability of reliable transport, routing and QoS negotiation protocols with functionality across a heterogeneous network environment.

Ad-hoc connectivity

Connectivity within the wireless world is supposed to be demand driven and to limit the amount of pre-configured or static routes. Networking will thus face a large number of links established in an ad-hoc fashion, which need to be maintained and controlled such that ubiquitous connectivity can still be provided to higher layers.

Support for Heterogeneous networks

The wireless world will consist of a multitude of different access technologies, interconnected by an inter-connectivity layer throughout the Network backbone. This backbone will need to be able to support any type of access network and therefore research into the connectivity between these access technologies needs to consider and support resource related issues arising in the support of various wireless and wire line access technologies. This also implies that both ad-hoc and infrastructure networks are to be considered, the network has to support gateways for ad-hoc / infrastructure network interconnection.

The aim of such support for heterogeneous networks is that all network differences become invisible to user applications and layers above the connectivity layer.

4.1.3.3.4 Context Management

Appearance and interface modality of applications executed on mobile communication equipment is dependent on many aspects including terminal type & capabilities, type and quality of network connection and contractual arrangements between subscriber and provider. Mobility introduces an additional dimension to this; applications may be used in varying surroundings and different technical and social contexts, including current needs, preferences, history, and behaviour of the user, location-related aspects like physical co-ordinates and velocity, as well as ambient conditions, technical aspects like bandwidth of the network and capabilities of the terminal, business rules that apply, etc.

Context information includes any information that can be used to characterize the current situation of a communication entity; mechanisms to manage the amount and variety of information need to be developed and suitable framework for their collection has to be designed.

The interconnectivity building block does not directly deal with all these introduced user issues, but will provide the technical realization by networking means that enable the context awareness in the Open Service Platform and above.

Context analysis

Location, physical environment, user behaviour and biometrics, social status and situation, subscription data, device and network characteristics and surrounding devices are some of the factors that can effect type, behaviour and quality of service that can be offered to the users. Context related information comes in several types, whereby division into primary (location, identity, activity, time, perceived QoS) and secondary (all others, such as infrastructure, physical conditions both of the user and his environment, available resources) types will simplify the analysis. This rough separation distinguishes between more and less important types of information, the primary context types can be considered as being more important than secondary types, i.e. when used for decision making, primary context information will always override secondary aspects.

Gathering and analysis of context information may range from being rather uncomplicated (e.g. location (position, direction, speed, etc.), identity and local time) to being rather challenging (e.g. the current activity context, which means that information about a users current engagements (being in a meeting, travelling, etc.). Task of context analysis is to support the decision making about whether and how/in which modality a service should be delivered.

Context-driven service provision

One of the current problems with mobile communication systems is that services are always offered in the same way using the same unaltered modality, regardless to the current user's status or neighbouring conditions. Knowledge of ambient condition or context would provide the means to make decisions about how a service should be delivered when users are in varying contexts. Based on this knowledge services may be delivered tailored to the current user context. To enable this, a context-register describing users' ambient condition should be established and regularly automatically updated. Additionally, every domain, like hot-spots operated by private or public bodies, enterprise domains operated by companies, and telecom operated domains, should have their own context-register. To enable global context awareness and management, it will be required to share context

information between these 'localized' registers and to dynamically update the context information of roaming users.

Using context information, service provision can be optimized by also taking information stored in specified profiles (i.e. user preferences, terminal capabilities, etc.), intelligent procedures and algorithms to interpret context and profile information and to apply the customized appearance of a service need to be developed.

4.1.3.3.5 Media Adaptation and Routing

Media Routing is the process of deciding an appropriate path through the network before a multimedia session. During the session, re-routing might be necessary. Media Adaptation is the process of adjusting the content format to the current transmission characteristics on the path during the session. Adaptive (Multimedia) Services are able to change their characteristics and service parameters during a session. Adaptable Services support re-configuration during of active sessions.

Media Routing

Media routing aims at selecting an optimized path between two nodes of the wireless world. The optimization criteria are among others:

- Availability of access networks
- The resource efficiency of the access networks carrying the data stream associated to one media type
- The mobility pattern of the communicating devices
- User preferences
- Content adaptation capabilities and availability of transcoding or filtering functions

Media Adaptation

The possibilities of adapting media to certain transport characteristics are determined by the codecs used to convert the media into digital information. Media Adaptation aims at utilizing the adaptations capabilities of coded media to improve service performance in the wireless world. In a wireless network comprising different access technologies the transmission characteristics might vary due to changing traffic load and mobility. Media adaptation will ensure that the service quality is optimized under given limitations of the available transmission links.

4.1.3.3.6 Network & Reconfigurability Management

The complexity of networks interconnected and interworking in the wireless world requires, compared to current telecommunication systems, advanced mechanisms for network monitoring, maintenance and management. This requirement is even more severe, when considering the flexibility required when new networks are to be connected. The advanced network monitoring and management mechanisms have to reach a degree of adaptability to even cope with the constantly changing topologies and therein connection capabilities within connected ad hoc networks. Part of the management tasks is the provision of flexible network control and resource management architecture and also of the components necessary to implement such a structure. Tasks of the architecture include simplifying and increasing the deployment of new networks by providing advanced self-configuration capabilities; this applies in particular (although not exclusively) for network models like ad-hoc networks. Network & Reconfigurability management is required to provide management functions and mechanisms for network integration for any possible network type that may be introduced.

Management Functions

There are several aspects of network management that have to be tackled, this includes mainly the management of the performance within the network, management of possible faults within the networked infrastructure, control and management of access and security in general, management of accounting for network utilisation and finally the management of configurations within network nodes. These management tasks are already non-trivial in the classical networks, but they become immense when mobile access networks, moving networks and ad hoc networks are connected. Despite the complexity these added networks introduce, the main management functions do remain similar

Resource and performance management has to measure the current performance throughout the network and has to allocate possible resources for scheduling mechanisms such as QoS guarantees. It has to constantly analyse the network performance and to react if the performance drops below set thresholds. Mechanisms like network performance simulations may be used to predict possible drops in performance and to proactively react to them.

Even if more fault tolerant protocols may be developed and deployed, there will always be the possibility for equipment failures or connection interruptions, part of the management framework must be sets of mechanisms to detect and monitor faults and to trigger appropriate actions to isolate and fix the failed section of the network.

Security management will require enhanced capabilities and functionality; security management in the here discussed heterogeneous networking environment is a complete aspect within the reference model.

Usage of resources and network services needs to be recorded, whilst some of the access networks may provide free usage, others may have temporally or packet based charging models in place, capable support for reliable accounting management needs to be developed.

Management of configurations and reconfigurations of networking equipment has the purpose to collect state information of nodes, and to limit the effects of various configurations within the network.

Network Integration

The management functions and tasks listed in the previous section apply even more, when dealing with a wide range of different interconnected networks. Additionally, the various types of mobility and the flexible nature of ad hoc networks magnify the possible points of failure and cause additional complexity to the management system. Main task to achieve interconnectivity must be the availability of a management system capable to flexibly adopt new networks. Network integration will require a number of mechanisms to:

- support integrated services,
- manage a multitude of access networks,
- manage and support a large number of different services,
- provide sufficient reliability,
- support network connectivity discovery using a unified mechanism throughout any connected network,
- use standard protocols to describe and negotiate the availability and the capabilities different networks and services.

4.1.4 Access

4.1.4.1 Rationale

The “Access” building block in the Wireless World groups all functionality and technologies which are directly related to the transmission of content (data) via a physical medium, thereby paying respect to the wide range of requirements imposed by users, operators, services and the environment (incl. governmental regulation). Since the natural way of facilitating “always connected” communications is wireless, the scope of the “Access” functionalities is focused, but not limited to wireless technologies and solutions.

4.1.4.2 Definition

Cited from *The Telecom Glossary 2000* [TG2000]:

> ***“access: 1.** The ability and means necessary to store data in, to retrieve data from, to communicate with, or to make use of any resource of a system. **2.** To obtain the use of a resource […]*

As the definition clearly shows, the central characteristic of communication is the fact that content is **transferred** from one place, person or device to another. Transferring content or its representations always requires a physical medium.

Since the goal of “Wireless World” is to facilitate easy, natural and intuitive communication for everybody & everywhere, the “Access” is a key issue, because some instance of access needs to be part of every communication.

4.1.4.3 Access in the Wireless World

The demand for higher data rates and system capacity is increasing. Therefore, the development of one or more new radio interfaces in parallel to the enhancements of existing ones will be necessary. These systems may comprise various wireless technologies for a range of deployments from very short range to global coverage, point to point, multicast/broadcast and planned/ad-hoc. These systems will be based on adaptivity (adaptive modulation, error control coding schemes etc.), spectrally efficient technologies (e.g. adaptive and multiple-antenna techniques, multi-user detection, interference cancellation…) and source driven transmission (e.g. joint source and channel coding) in order to increase the individual link capacity. System capacity will be increased by, for example, flexibility in the scheduling of users, self-organisation, adaptive and multiple antenna techniques and adaptive/dynamic spectrum use combined with scalable link technologies (including impacts to Layer 2/3). To ensure the Always Best Connected multi-access vision, the different radio interfaces must coexist, and co-operate, with existing radio systems by inter-working mechanisms and radio re-configurability (programmable hardware). Newly developed radio interfaces must meet all applicable regulatory requirements and standards for public health at the time of deployment.

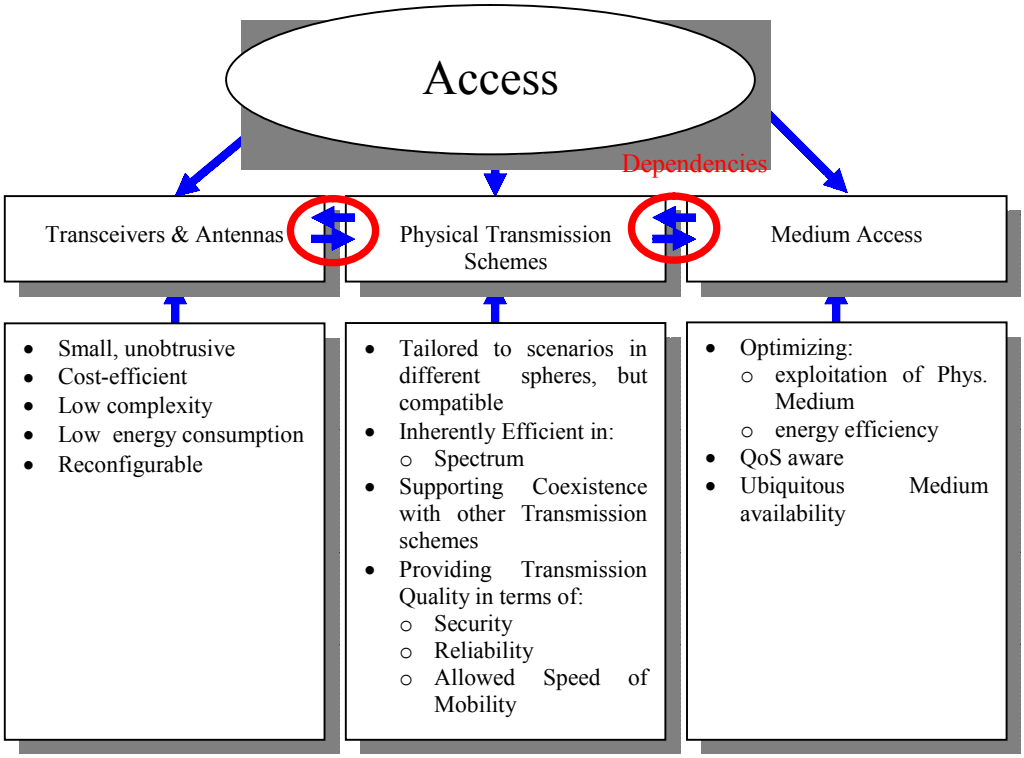


Figure 4-7: Structuring the "Access" Block. Components and underlying assumptions

The generic components identified which cooperatively form the "Access" Block and provide its functionalities are the **"Transceivers & Antennas"**, the **"Transmission Schemes"**, and the **"Medium Access"**. The assumptions made in the process of defining the features of these components are displayed in Figure 4-7. The following subsections give a brief description of each component.

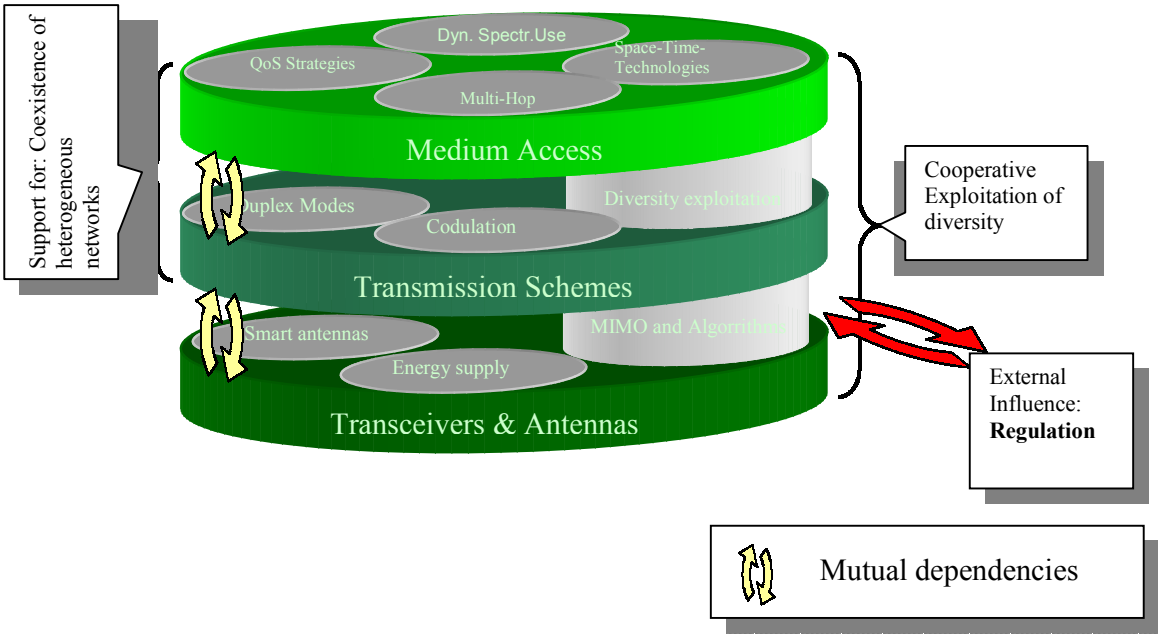


Figure 4-8: "Access" Reference Model

4.1.4.3.1 Transceivers & Antennas

The transceivers and Antennas Domain encompasses all functional entities related to the physical transmission of signals. The common understanding is that the transceivers will have to be small and unobtrusive, cost-efficient to implement (which means lowest possible complexity), consume minimum power and have the ability to be reconfigured to specific scenario needs and different air interfaces. Antenna concepts, together with functionalities from the “Transmission Scheme” domain and the “Access domain” facilitate the exploitation of diversity and thus contribute to increase link (and system) capacity.

Transceiver architecture issues

A transceiver is a building block that interfaces between the user and the transmission medium, i.e. the free air in the mobile communication systems.

The principal task of today's communication engineers is to find an optimal trade-off between the physical performance measures of a receiver - power and bandwidth - and signal processing complexity, or equivalently power consumption. Ideally, the receiver should, of course, approach the information theoretic limits while hardly consuming any power nor occupy much chip space

Another key decision in the design of a transceiver is the choice of the technology. GaAs circuits achieve the best results in critical blocks such as the low-noise amplifier and the power amplifier. In this area, various technologies such as Bi CMOS, digital CMOS and SiGe are potential candidates.

High efficiency power amplifier design

Today's wireless systems impose challenging requirements on the power amplifier (PA) designer. A mobile terminal PA has to be as efficient as possible to conserve battery power. Base stations also have efficiency specifications due to power and cooling limitations.

Linearization techniques for RF transmitters

In future wireless communication systems, complex modulation methods will be used to increase bandwidth efficiency. These types of modulations may require transmitters using highly linear amplifiers. In practice, however, there is a trade-off between efficiency and distortion. Linearizations schemes will have to be developed that reduce the amount of distortion added by a transmitter. In this context, concepts of feed forward, pre-distortion, and feedback techniques will gain importance.

4.1.4.3.2 Transmission Schemes

The “Transmission Schemes” domain encompasses the concepts addressing the conversion of (mostly digital) data into signals suitable for transmission over physical channels. The signals have to fulfil various requirements: they need to be tailored / adaptive to scenarios identified in different spheres (see 4.2.1), but compatible on the other hand, to reduce complexity in the “Transceivers” Domain and allow for easier reconfigurability. They further need to be inherently spectrum-efficient, supporting spectral coexistence with other transmission schemes. Other requirements which have to be met by the transmission schemes include the provision of transmission quality in terms of security, reliability and allowable speed for mobile users and terminals.

4.1.4.3.3 Medium Access

A main characteristic of the "Access" domain in the wireless world will be the use of intelligent and adaptive Medium Access strategies. They are key features of any radio system and take care of efficient exploitation of radio resources and Link adaptation (modulation and coding) to the current quality of (each of) the carrier/s. They can choose the optimal radio access depending on service, environment, and user profile. In multi-radio environments, inter spectrum MAC is an important issue as well as Interference/Energy aware access protocols (wait for better C/I before transmitting). Reduction of Interference from systems is achieved through spatially differentiated Medium Access with smart Antennas. QoS support is identified to be a generic function of "Wireless World" systems. Advanced ARQ protocols in the Medium Access domain will help to support this goal. Multi-Hop Solutions are foreseen to be of utmost importance due to their ability to trade capacity for radio range and substantially reduce necessary transmission power in broadband radio access networks. Medium Access in all cases is accompanied by Radio Resource Management Functionalities.

4.1.4.3.4 Regulatory Framework

From a regulatory point of view, the most important event in the timeframe of the "Wireless World" is the World Radio Conference (WRC) 2007. Spectrum requirements for Wireless World systems will have to be identified until that date in order to have the additional spectrum available at the time of market inauguration of new systems. A wide variety of other spectrum-related topics like spectrum-sharing and –co-farming will come into focus once the regulatory boundary conditions are fixed. Therefore WRC2007 presents an important Milestone in the Wireless World Timeline.

4.2 Aspects of the Wireless World

4.2.1 Spheres

The sphere concept adds another fundamental dimension to the Wireless World reference model. The spheres represent the backdrop in which rich communication services may be described.

The human being is in the centre of the concentric set of spheres, demonstrating the user-centric approach generally adopted in the work on the Wireless World.

The spheres of the Reference Model stand for different communication contexts. Driven by the horizontalisation introduced by 3G's mobile Internet, future vertical applications and services will draw together a multitude of wireless technologies in an ad-hoc manner. Those elements will be around us like a number of spheres in which we live.

CEs do not "exist" in a certain sphere but have to be placed there logically depending on the nature of the communication they are involved in (e.g. the location of the communicating entities). For example, communication between two CEs in a global sphere can include "local sphere communication" to become possible. The communication between elements in non-adjacent spheres is assumed to always take place via one or more elements of an intermediate sphere.

The precise number and nature of the different spheres cannot be finalised at this point in time. The final sphere structure will be a representation of the prevailing business model. Below we give a short description of the spheres used in this document, the:

- Personal Sphere

- Local Sphere, and
- Global Sphere.

4.2.1.1 The Personal Sphere

The closest interaction with the Wireless World will happen with the elements that are the nearest to us or might even be part of our body. Communication facilities will be contained in clothes and wearable items. On request they will start to discover each other and distribute a common virtual terminal over us.

This Personal Area Network (PAN) vision is certainly feasible in today's technology but needs much closer integration with the overall concept. As electronic communication will happen "at" our body power issues will be critical for PANs together with fast, flexible and automatic configuration and privacy protection. Much additional research is needed for the evolution of PANs to full constituents of the Wireless World of tomorrow.

In the Personal sphere we also find the elements of the real world around us. Currently we do not interact with them but in future we will expect that they take notice of us, that they start to interact with us and turn into personalized items rather than general purpose devices. TV sets should know what programs we are interested in, toasters might want to deliver toast with the right level of toasting and fridges might want to tell us what we probably would like to re-order as we might run out of milk over the weekend.

As the difficulty of using current technologies is irritating to many people, learning and adapting environments will start to address real and fundamental user needs. While personalization as a technology might become part of nearly all devices in the future what will be important is the possibility to personalize several devices with a common approach or at the same time rather than individually. For example, a non-smoker or vegetarian will not want to explain his preferences 100 times in different ways, to his different devices. Similarly a user will expect at least consistent errors when interacting with devices using speech. Therefore, we believe the immediate ad-hoc environment to be an important part of the Wireless World model.

4.2.1.2 The Local Sphere

One step further we interact with people around us as well as with more complex systems like cars. We may want to talk to them or just relay information through them. It is believed, that in the future our wireless possibilities should enable an easier and maybe richer interaction with close-by people than with people on the other continent. On the other hand, "closeness" can also be seen as being part of a close net of people with whom we want to be closely interconnected and where we would like to be kept informed about their wishes and thoughts quickly. Current chat communities are just a glimpse of what people might desire and enter into in the future.

4.2.1.3 Global Sphere

The outmost sphere, most remote from our immediate real world, represents our virtual world. It is likely that our presence in our self- created virtual world will be as important to us as presence in the real world. This trend is already visible in today's explosion of services and the perceived realism of advanced games. In our virtual world we can stay in touch with our (semantic) agents, knowledge bases, communities, services and transactions. The Wireless World will be the way for us to become permanent residents in our virtual world. A deep understanding of this world is necessary to develop Wireless World technologies that really satisfy our fundamental needs.

Figure 4-9 below illustrates the sphere dimension of the Wireless World Reference Model.

Figure 4-9: Illustration of the Sphere dimension of the Wireless Word reference Model

4.2.2 Service Characteristics

Another Dimension of the Reference Model are the different “Service Characteristics” which have implications mostly on the Cyberworld, but also on the Open Service Platform and Interconnectivity Blocks (see Figure 4-10). Since the reference model tries to represent a user-centric approach, the Service Characteristics are probably the most important issues in the reference model, because they are the most prominent point of contact a user has with any new system or network. All functional elements of the reference model will therefore have to support the goals imposed by the service characteristics.

Service Characteristics

- Ambient Awareness
- Personalization
- Adaptability
- Ubiquity
- Consistency
- …

Figure 4-10: Service Characteristics

4.2.2.1 Ambient Awareness

Future services become personalised when they are tailored to the context and adapt to the changing situation. The situation in this sense consists of many aspects, like objects of the communication space and causalities between them, but also ambient/situational conditions and business rules that apply.

In the future wireless services will be tailored to the contexts of the individual communication spaces. The services will automatically adapt themselves to situational changes. The mobile user moves around and thus the ser-vices deal with a dynamic user environment. The adaptation to the situation in a context is hidden from the user and provides him with optimal experiences and added value. Vice versa, the environment of the user can be influenced by the presence's and activities of the user and adapt itself accordingly.

Advances in sensor technology are conditions to reach further adaptation of services to - and in co-operation with - the environment of users. Many devices in our current world already adapt in some form to their operating environment. One example is the television set that adjusts its image contrast to the ambient lighting level. 'Intelligent I/O behaviour' can be used to adapt the output characteristics depending on the situational context (e.g. mail message to car audio system or textual on cellular phone), but also the input characteristics should change in many situations (do not bother the user with long lasting search interaction, but combine the context information with the basic intention that was before-hand communicated by a few interactions). This intelligent I/O behaviour would demand the development of multi-mode user inter-faces and corresponding support functions in the various consumer devices as well as in the service adaptation network.

4.2.2.2 Personalization

One of the major requirements for future services is the provision of mechanisms for ser-vice personalization. Personalization provides the information space for modelling each individual in the service platform i.e. user preferences, the quality of his senses, user location/ environment, contexts, his network and terminal capabilities. It is the "directory" of the communication space enhanced with information on contexts and user profile.

Personalization is considered as being the key factor for success/failure of mobile devices and services. Information and services become increasingly tailored to individual user preferences and characteristics. The primary goal behind personalization is to make the usage easier and the perception of the communication space richer, and to enable personalized filtering of the global communication space into each individual communication space. Profile information has to be adapted dynamically using automated learning functionality.

In general, a further development of the distributed personalized service architecture is needed. All the personalization aspects like e.g. user preferences, role/task, location, time, network, and terminal have to be integrated and the relation between the aspects must be studied. Insight into added value according to the user perception is necessary and needs to be considered in the design of personalized services and personalization supporting architectures.

4.2.2.3 Adaptability

Adaptability is one of the key research areas for future service architectures. It is the glue between contexts, personalization and situation awareness. It has implications in the structure of the services to allow adaptability and is the engine which instantiates a context at a certain moment in time in a certain situation.

When circumstances change, then the behaviour of a service changes according to the user personalisation and situation awareness – usually automatically without explicit user evolvement. Typical situations when adaptation should take place include a substantial change in characteristics of connectivity, entering into a new service domain, or changing terminal device in the service session.

Adaptability cannot be only reactive. When the battery dies or the connectivity breaks, many actions become impossible. However, something could have been done beforehand. Therefore, adaptation must also be proactive, which, in turn, requires predictability of the near future. An important question in predictions is to distinguish between the situations in which the user behaviour seems to be predictable and those being unpredictable.

4.2.2.4 Ubiquity

Services in the wireless world have to be ubiquitously available. Restrictions arising from transport or terminal capabilities should not render a service inaccessible. The wireless world has to implement appropriate functions to adapt the services and/or the transport such that services are ubiquitously accessible.

Service adaptation is supposed to lower the demands of the service concerning transportation and presentation capabilities. Adaptation decisions have to be always based on an analysis of service quality impacts and service importance.

Adaptation of the transport system is to be exploited for the achievement of ubiquitous service accessibility. Transport priorities are to be adjusted within a transport network or new routes are to be established dynamically. The resource costs connected to the realisation of the required transport capacity have to be matched against the service quality and possible service adaptation means.

4.2.2.5 Consistency

The wireless world allows the access and distribution of information to any participating element. No architectural limitations are made to the distribution and access of data, as it is expected that different data management strategies are required to support the services in the best possible way. Still, a main requirement on all management schemes is the maintenance of data and information consistency. The wireless world is supposed to support services by providing appropriate mechanisms to fulfil this requirement.

The mechanisms of the wireless world are assumed to ensure consistency by prohibiting unauthorized access and supporting the management of distributed information. Replication of data and modifications should under no circumstances lead to any inconsistencies between the distributed copies of information elements. It is thus not only necessary to protect data from unauthorized access, but also co-ordinate authorized access to distributed data.

4.2.3 Business Models

Business Models mainly influence the Cyberworld Block as far as functionalities are concerned, but depending on which Client/Provider relationships emerge in the wireless world, they may cause the involvement of different communication spheres.

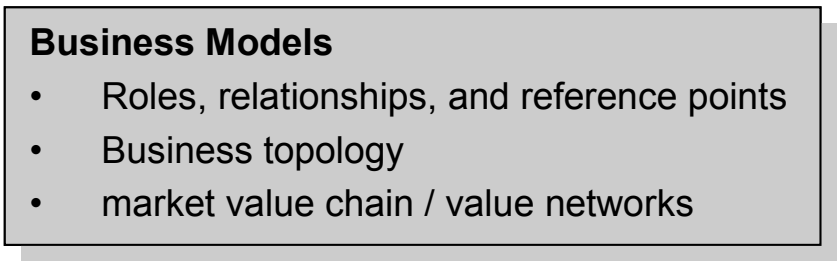


Figure 4-11: Business model aspects

The convergence of traditional telecommunication systems, Internet based systems and the emergence of new application needs new business models. The borders between traditional roles and administrative domains: net-work provider, content provider, service pro-vider retailer are blurring. A user may be-come service provider (ad-hoc networking), or content provider (music etc.), or service provider (peer-to-peer), or retailer. Addition-ally the roles may change in the same active context implying a very flexible business model.

The first objective of the research is a model for the description of relationships between involved parties in a global business community. Based on these relationships, a business model defining roles and reference points should be developed. 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 standardised points of contact and information ex-change between business partners. Such a business model for the wireless world is a prerequisite for the definition of a service architecture that supports the required functionalities of the whole business life cycle. The business model envisaged provides also a value chain oriented viewpoint. Potential scenarios, including the whole process from service creation up to accounting and billing have to be analysed.

4.2.3.1 Roles / Relationships

On a functional level, business models describe the architecture of a product or service. So although the environment is liberalised and competitive, the co-operative relationships between service providers, with network operators and with customers is vital when providing end-to-end services, especially in order to react flexibly to the customer's requirements for tailored service delivery. The introduction of advanced services should not be hindered by the lack of co-ordination between the stakeholders regarding management of these services. There must therefore be a consistent understanding and functionality across all domains involved in managing such services.

A role is a specification concept describing behaviour. A role may be composed of several roles. A role serves as a placeholder for an object. An enterprise role is defined in terms of the permissions, obligations, prohibitions and behaviour of the enterprise object fulfilling the role. A role thus identifies behaviours to be fulfilled by the enterprise objects comprising the community. An enterprise object is an object that fills one or more roles in a community.

The business model describes the different parties involved in service provisioning and their relationships to each other. A small number of roles are defined, which reflect the major business separations of a complex telecommunications and information market: consumer, retailer, broker, third party service provider, content provider, and connectivity provider.

Two important notions in business models are administrative domains and reference points. An administrative domain is the unit which owns certain parts of the system. Reference points are interfaces describing the interactions taking place between the different roles.

4.2.3.2 Business Topology

Business topologies basically, follow the idea of having different administrative domains trying to specify where what functionality has to be provided in a distributed telecommunication system. A major question behind this is: Where to realize the intelligence of a system (in the terminal, in the backbone…). A concrete business topology can only be decided by having a close look onto the specific technologies that have to be applied to the system. Therefore, the business topology combines the functional viewpoint with a more technology oriented viewpoint.

4.2.3.3 Market Value Chains/Networks

In the simple enterprise model, the primary purpose of a business model is to identify interfaces, which are likely to be of general commercial importance. In order to do this, a number of roles are identified which describe a reasonably well-defined business activity which is unlikely to be subdivided between a number of players. In addition, it should be anticipated that the roles would have a reasonably long existence. The interfaces surrounding the role must persist for some time in order that customers and suppliers of the role can successfully interact with it. In addition, many players may choose to take on the same role in which case the role becomes a competitive activity; also, the role needs to be reasonably stable for a successful competitive marketplace to emerge.

According to the simple enterprise model, services flow through various functions or organisations such as service creation function or service provider, brokerage function or broker, etc. Based on this value flow, it is possible to classify interconnection types.

In understanding the roles and the nature of the services flowing between them, it is possible to identify more generic features, which are needed to support the roles and the interfaces between them. As well as the services, other entities must pass between roles including information and contractual and legal obligations.

Value chain, complete value chain, and primary value chain: A "tree" of roles are connected together to make a service. The total set of roles involved in producing a service and the way they pass intermediate services between the roles is called the complete value chain. The set of roles which form the only principle activity of a generally recognised industry which produces the service are the primary value chain. All the other roles in the complete value chain will be providing support services for roles in the primary value chain.

The simple enterprise model already made a number of references to value chains. Just like traditional value chain models, these types of layered models are characterised by a rather strict hierarchy and linearity dictated by the different layers in traditional telecommunications systems. As the linear hierarchy and sequential dependencies associated with telecommunications systems are decreasing, these models are increasingly starting to resemble the more general value systems or value network models.

The value network concept attempts to broaden the value chain perspective by considering links with both upstream and downstream value chains. In this view, a value network is a set of relevant activities behind a product or service offering. These activities, and not the actors performing them, are the primary nodes in the network. The relationship between the nodes may consist of flows of materials, services, information, or financial resources.

Actors in a value network may be responsible for one or more activities and may participate in more than one value network. They may be suppliers, producers, intermediaries or users of a certain good or service. Among the actors is the end customer, who not only receives and (usually) consumes the value created, but may also participate in value creating activities.

4.2.4 Functional Aspects

Functionality in the CEs is divided into three main aspects: Content Processing, Control, and Management functions. This separation reflects differences in characteristics and requirements of the functions.

4.2.4.1 Content Processing

The Content Processing functions are related to processing, transforming and end-to-end delivery of data exchanged between entities in the Cyberworld. These functions are executed by or for the entities in the Cyberworld. The content provisioning functions can further be grouped according to three different roles: sender, receiver, and intermediate. It should be noted that the roles are not exclusive.

In the sender role the primary concern of the content processing functions is to prepare the requested information into appropriate format. In the receiver role the primary concern is to render and/or store the received information in proper format. In the intermediate role the primary concerns are to transform the content from one presentation format to another, to synchronize multiple inputs, and to combine multiple inputs to a single output.

4.2.4.2 Management

The Management functions are primarily executed by service, interconnectivity, and access providers in order to make services available for entities in the Cyberworld. In some cases—in personalization, for example—some Management functions are executed for end-user. The usage of these functions needs to be properly protected and controlled.

The basic division of management functions includes functions related to service provisioning and functions related to service characteristics. The service provisioning related functions contribute to the Operation Support System (OSS). This functionality can further be divided into network (interconnectivity) management, service management, subscription management, and subscriber accounting and identity management.

The service characteristics related management functions are primarily related to personalization, ambient awareness and consistency. They provide means to maintain user preferences.

4.2.4.3 Control

The Control functions handle all control messages between entities. They are executed for the entities in the Cyberworld but never by them. Therefore, the usage of these functions needs to be properly protected and controlled. Moreover, the Control functions need to be executed in a timely fashion.

The most natural way of grouping control functions is based on reference points. Another useful classification is based on the life-cycle of service execution. Firstly, there are functions related to service activation. This group includes all control functions in all reference points needed to start the execution of the service. Secondly, there are functions that are executed during the service execution. This large group can further be divided according to objectives of the function execution: 1) functions that change the behaviour of the service execution (service adapts to changes in execution environment, for example) and 2) functions that are needed to maintain the service execution (rerouting due to terminal mobility, for example). Thirdly, we have the functions related to the termination of service execution.

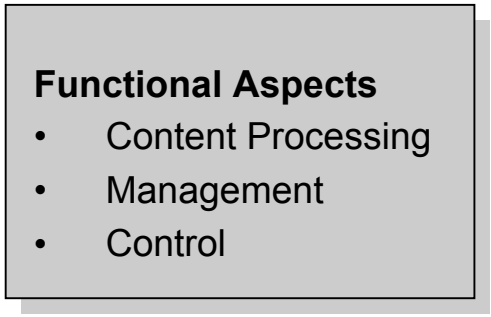


Figure 4-12: Functional aspects

4.3 Reference Points

The Building Blocks which form communication elements are connected by Reference Points. The early identification and specification of these reference points will enable more flexible communication systems than we will have with 3G systems. There are “vertical” and “horizontal” reference points. The vertical reference points are defined interfaces between the building blocks of the communication elements. A connection can also take place between communication elements which reside in different spheres using “horizontal” reference points.

Reference Points within a Communication Element:
- CP – Cyberworld/Platform
- PI – Platform/Interconnectivity
- IA – Interconnectivity/Access

Reference Points across Communication Elements:
- CC – Cyberworld/Cyberworld
- PP – Platform/Platform
- II – Interconnectivity/Interconnectivity
- AA – Access/Access

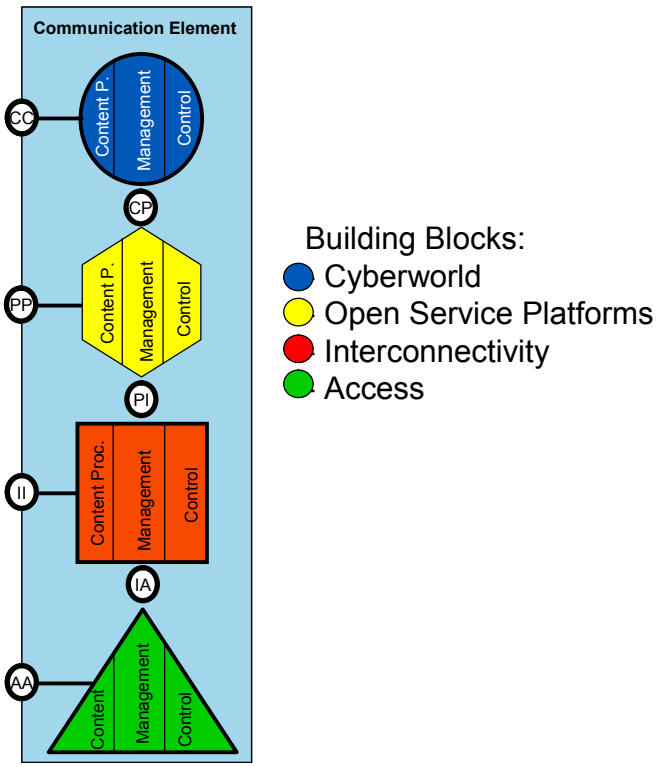


Figure 4-13: Building Blocks of Wireless World Communication Elements

The reference points between the building blocks are crucial elements for the precise technological description of the model. The functionalities which the different blocks have to provide at these reference points will have to be well-defined, complete, and generic in order to assure the proper functioning of the model and to allow treating the building blocks as “Black Boxes” from the viewpoint of the adjacent blocks. The reference points can be divided into two categories:

1. Those which provide an interface between different building blocks in one communication element.

2. Those which “virtually” link equal building blocks of different CEs, thereby possibly spanning one or more spheres.

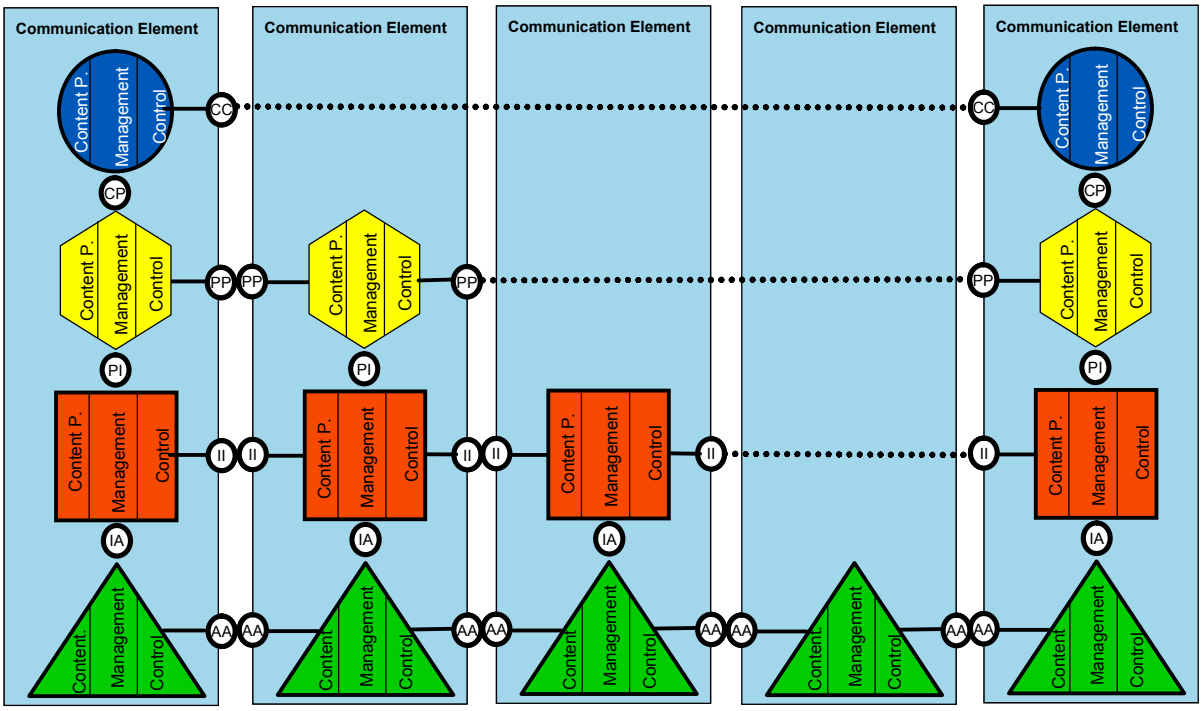


Figure 4-14: Different options to interconnect Communication Elements

Figure 4-14 depicts different options to communicate between building blocks. Furthermore, it is shown that not all communication elements have to provide all building blocks (e.g. to connect two different spheres using a dedicated transmission technology a communication element only consisting of an access building block might be enough). Nevertheless, a building block can only communicate logically with a building block of its own type in a different communication element using a physical connection to a building block in its own communication element providing the required reference point (for Figure 4-14 this means: diagonal connection are not possible).

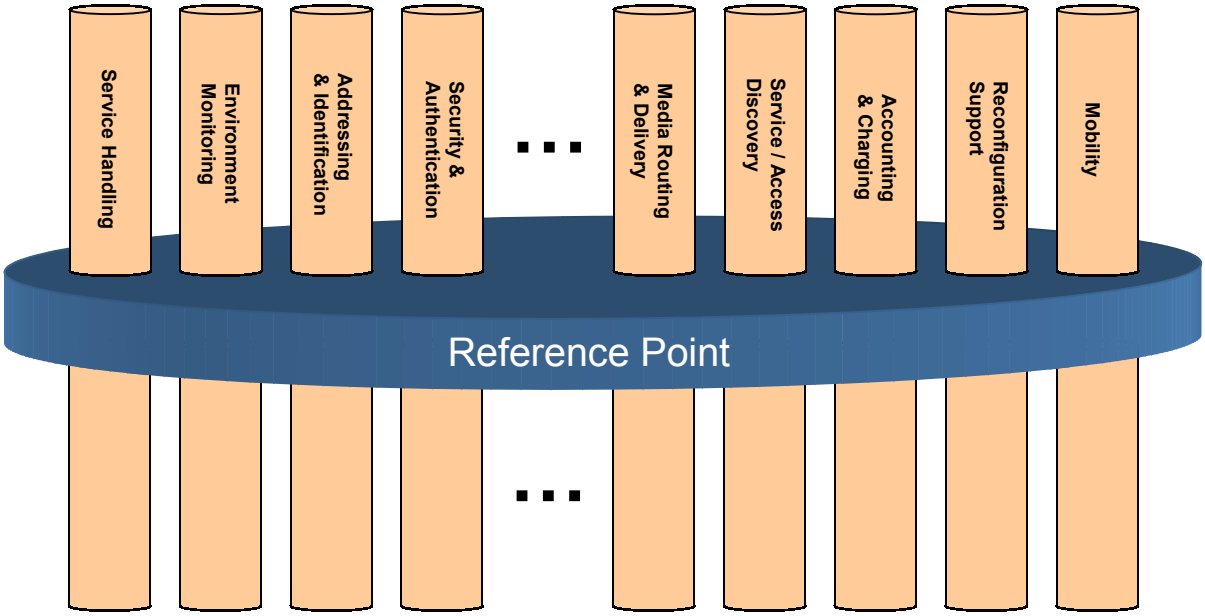


Figure 4-15: Generic Functions to be provided at Reference Points

The reference points represent well specified points of contacts between the building blocks. This specification will cover so called **generic vertical functions** that have to be provided by all reference points. Vertical functions provide certain functionality through all the building blocks by addressing the dedicated problems and technologies of each building block. At the moment, the WSI project has identified nine different functions (see Figure 4-15) that have to be provided.

Note that the list of vertical issues in Figure 4-15 is not claimed to be complete, since totally new services, probably unknown as of today, may raise totally new “vertical issues”.

The service architectures for the Wireless World will have to cope with things like numerous service providers, always connected users, automatic service adaptation, context awareness and new IP devices. Aspects like dynamic service discovery and service provisioning in (for users) unknown environments and the personalised services usage requires new mechanisms.

The generic functions will enable providers to make their products and services available in a flexible way. The same will make it possible for users to discover and use the desired service. Assembly and configuration of contexts composed of various service offers is needed to achieve the requirements stated explicitly or implicitly by the user.

4.3.1 Between Building Blocks of one Communication Element

The detailed definition of the reference points will be the work of future standardisation activities. Before such work can start, however, the principles of how communication works at reference points and how such communication is to be specified must be defined. To address these issues definitively would have exceeded the boundaries of the study undertaken within the WSI project.

Assumptions made on reference points by the project include:

- Communication among building blocks is established dynamically, i.e., in the normal case there are no pre-established configurations.

- Communication across reference points is asynchronous and uses messages exclusively.

- Function distribution among building blocks follows the principles of “hiding” minimising message traffic and delay

- The first message to requesting a service and starting a new transaction normally carries no destination, but the destination is determined by a selector function included in each building block’s control function. Further messages needed to conclude the transaction are directed to particular instances in the system.

- Communication across reference points is capable of supporting several protocols without requiring knowledge about the protocol’s specifics.

4.4 Reference Modelling Example

A working example of reference modelling is presented in Annex A. The example is mostly focusing on Cyberworld level but illustrates the overall modelling approach on other levels as well. The example is based on reverse engineering of a futuristic national research project "Cyphone" carried out at University of Oulu during 1998 - 2000.

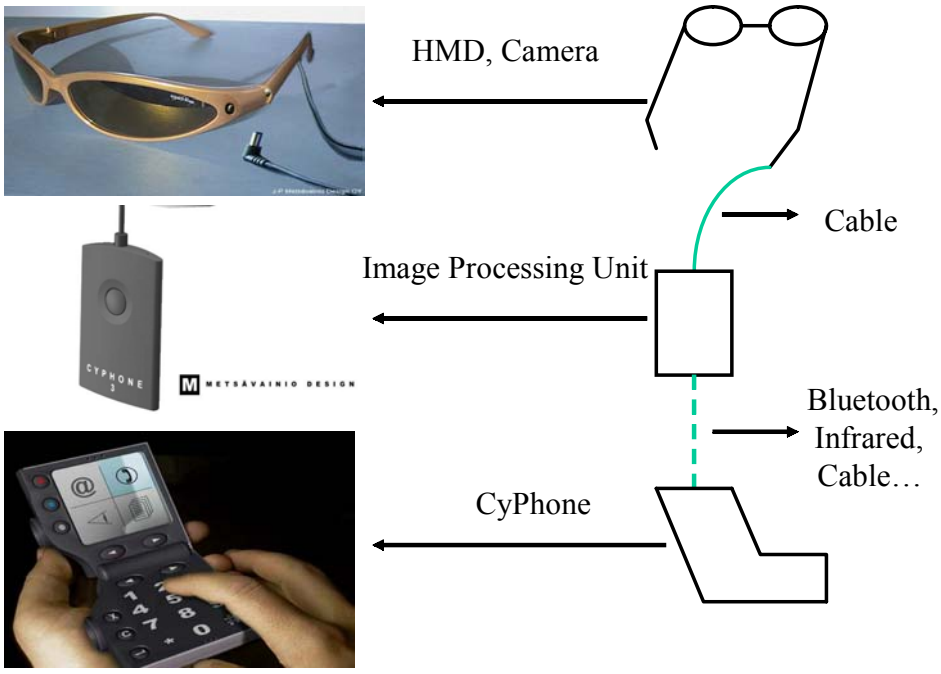
5 Conclusions

The WSI Reference Model describes the elements of future wireless communication systems. It identifies, how these elements can interact, what functionality they have to provide and how the elements can be assembled. This model has already been introduced to a broader audience (e.g. WWRF, WWRI, WWI). Purpose is to generate an impact on the international research community, keeping in mind that this community will specify the architecture of the Wireless World over the next years.

Annex A WSI Reference Model Case Studies: CyPhone

Outline of Research Work

Introduction: CyPhone System

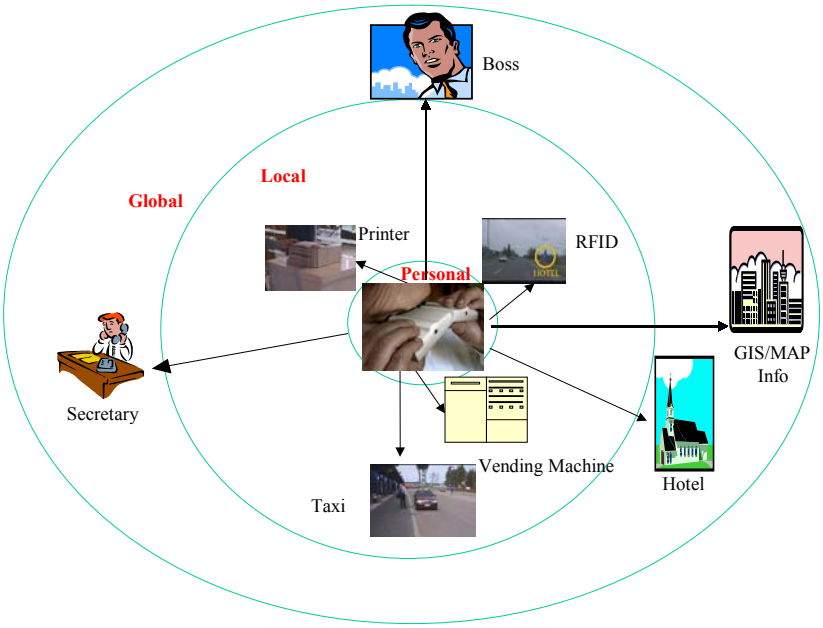


Introduction: CyPhone Services

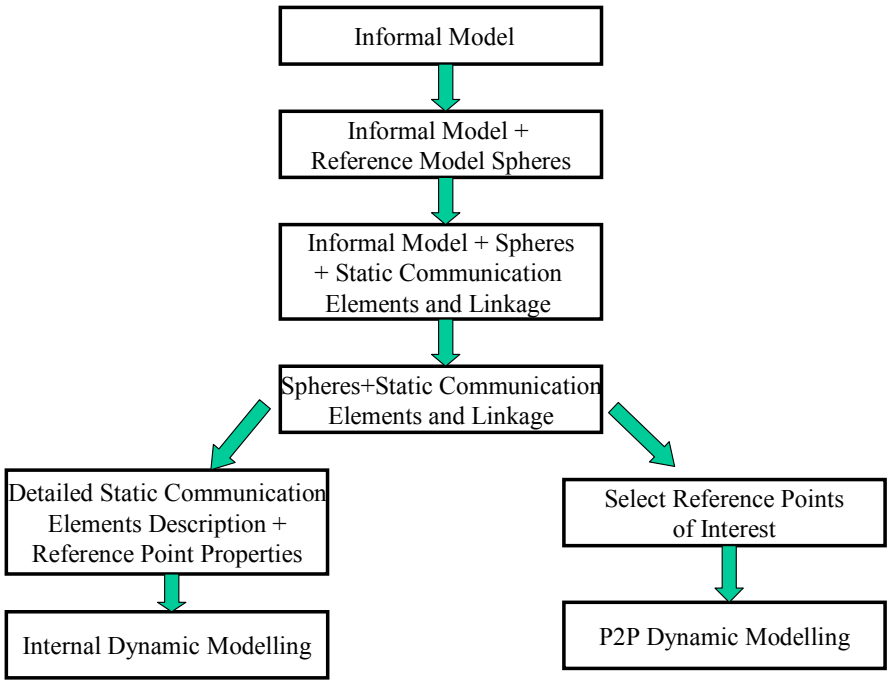
CyPhone with the support of Head Mounted Display can offer excellent Augmented Reality services.

An example of using Cyphone AR ability for guidance and navigation service.
A major challenge is synchronization of real and virtual worlds.

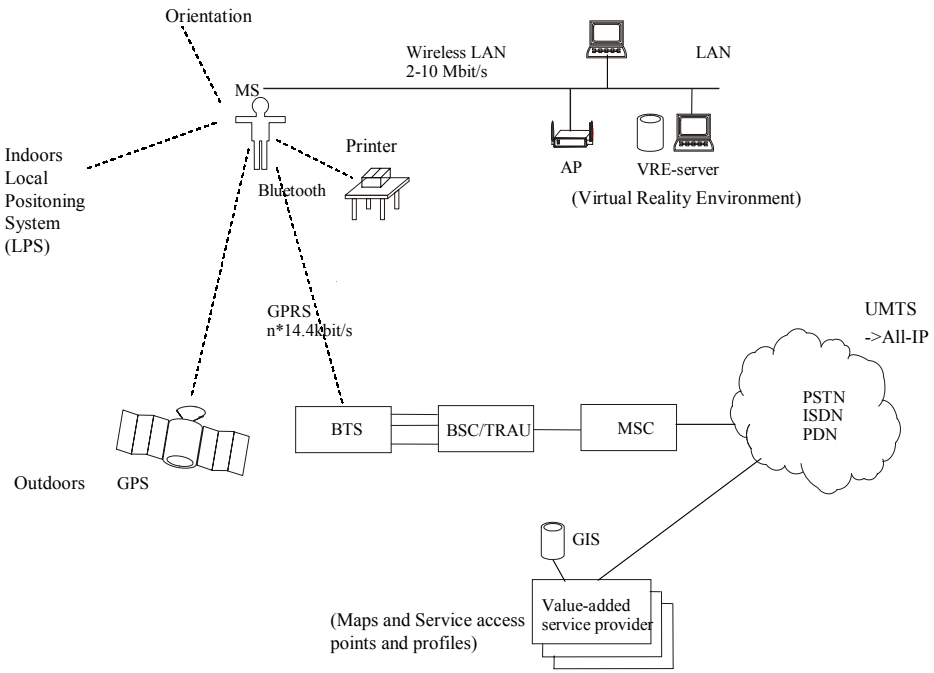
Introduction: CyPhone Taxi Trip Scenario Spheres

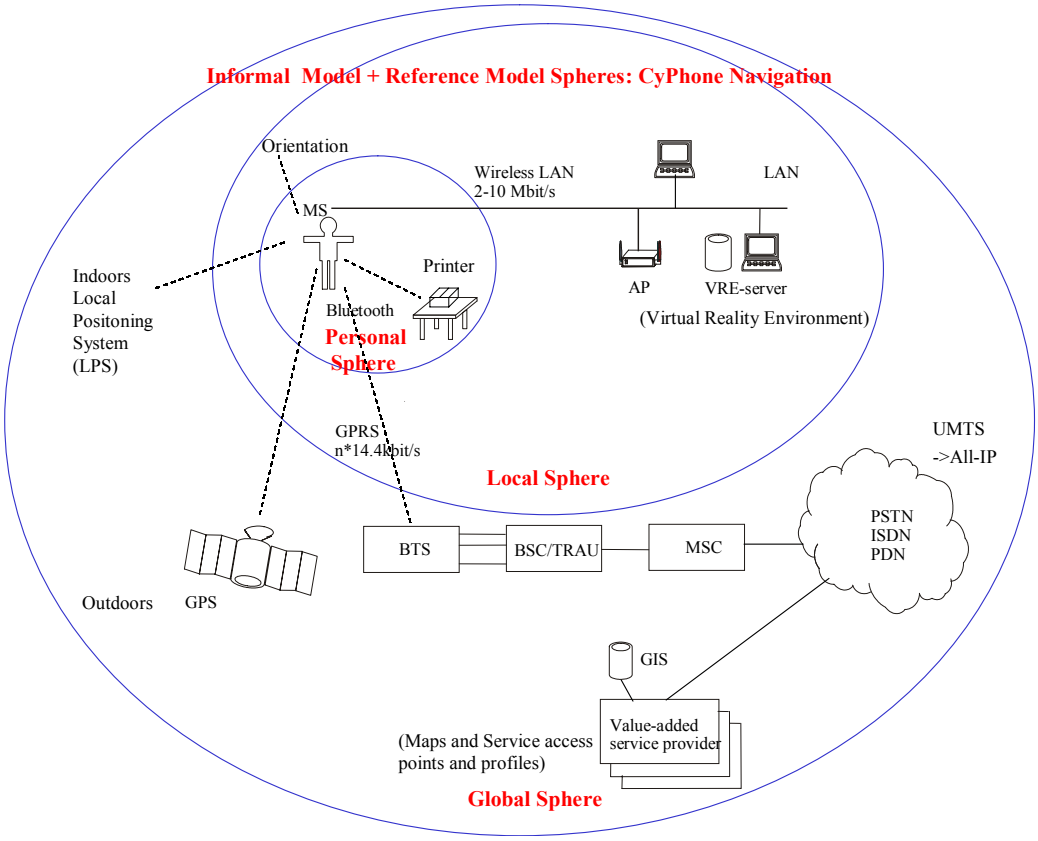


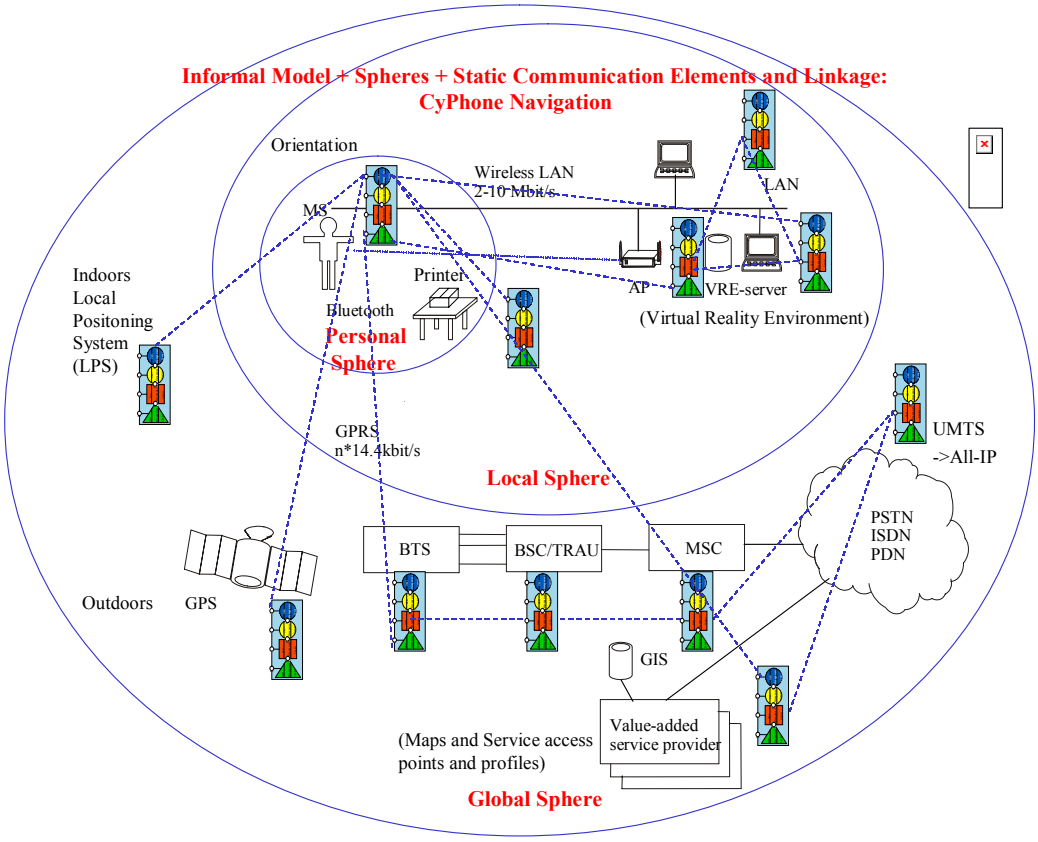
Wireless World Reference Modelling Procedure

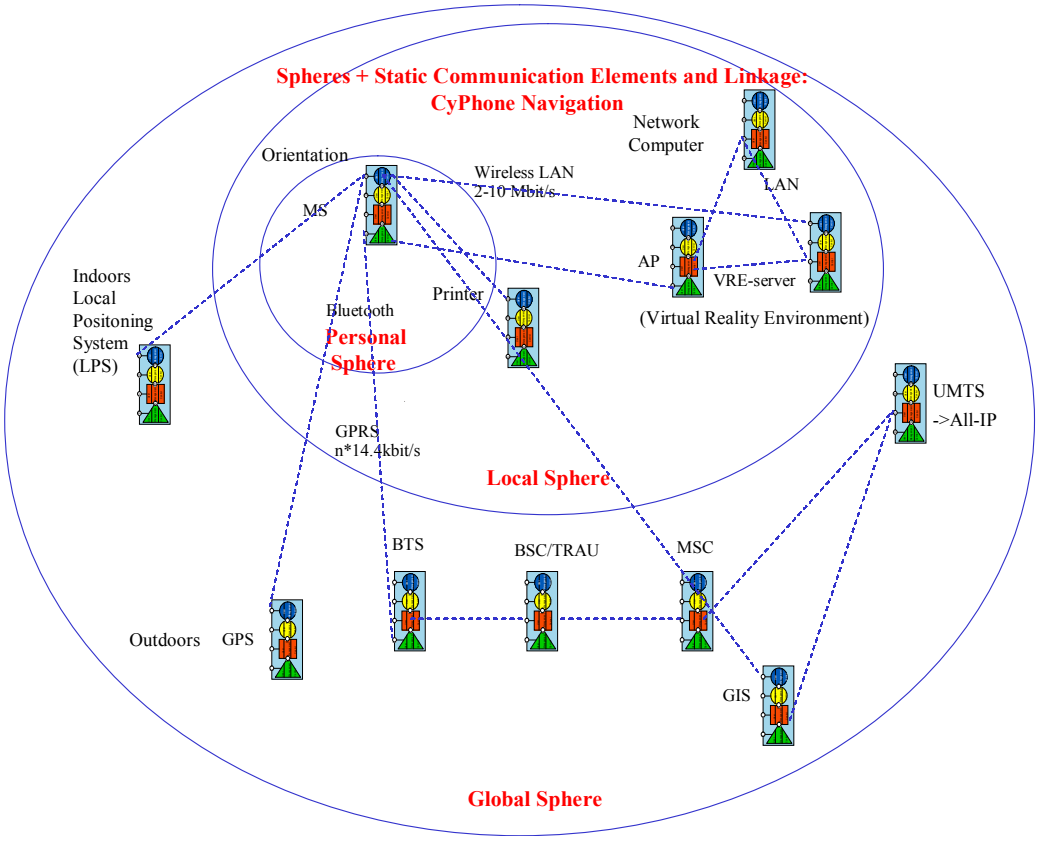


Informal Model: CyPhone Navigation

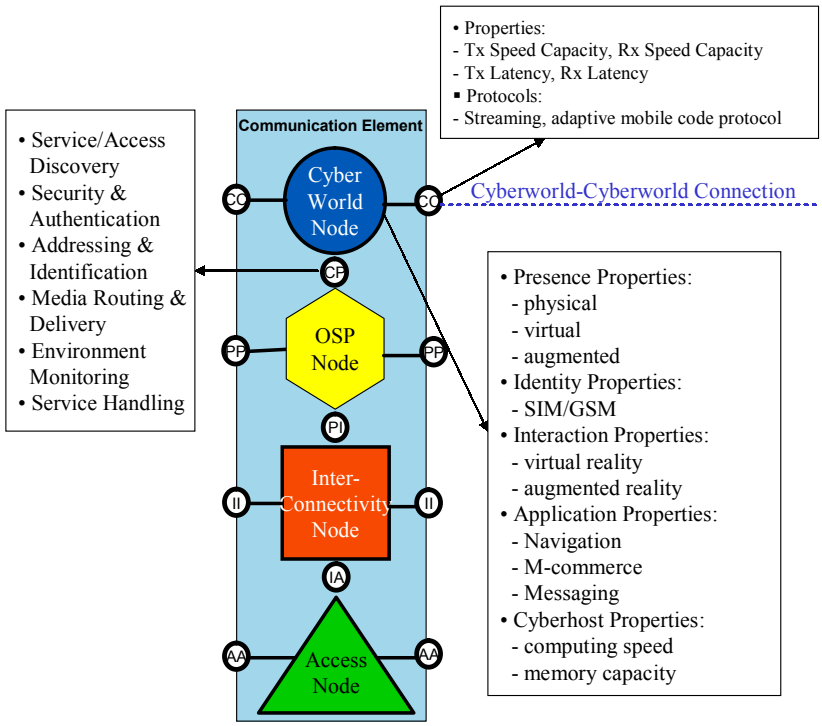



Informal Model + Reference Model Spheres: CyPhone Navigation
Orientation
Wireless LAN
2-10 Mbit/s
LAN
MS
Printer
AP
VRE-server
Indoors
Local
Positoning
System
(LPS)
Bluetooth
Personal
Sphere
(Virtual Reality Environment)
GPRS
n*14.4kbit/s
Local Sphere
UMTS
->All-IP
PSTN
ISDN
PDN
BTS
BSC/TRAU
MSC
Outdoors
GPS
GIS
Value-added
service provider
(Maps and Service access
points and profiles)
Global Sphere

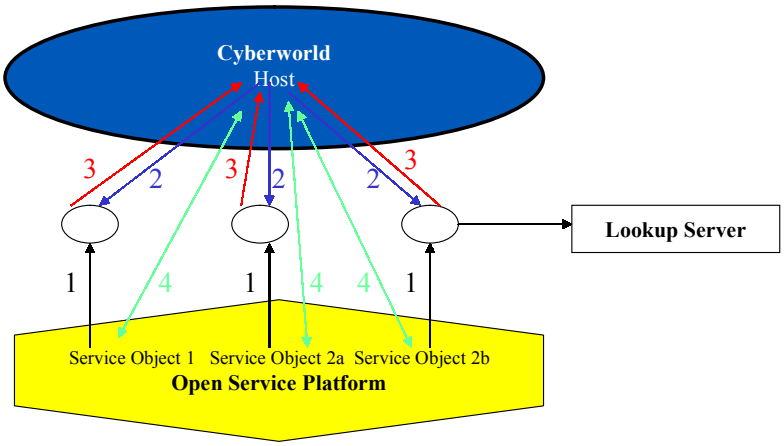

Informal Model + Spheres + Static Communication Elements and Linkage:
CyPhone Navigation
Orientation
Wireless LAN
2-10 Mbit/s
LAN
MS
Printer
AP
VRE-server
Indoors
Local
Positoning
System
(LPS)
Bluetooth
Personal
Sphere
(Virtual Reality Environment)
GPRS
n*14.4kbit/s
Local Sphere
UMTS
->All-IP
PSTN
ISDN
PDN
BTS
BSC/TRAU
MSC
Outdoors
GPS
GIS
Value-added
service provider
(Maps and Service access
points and profiles)
Global Sphere



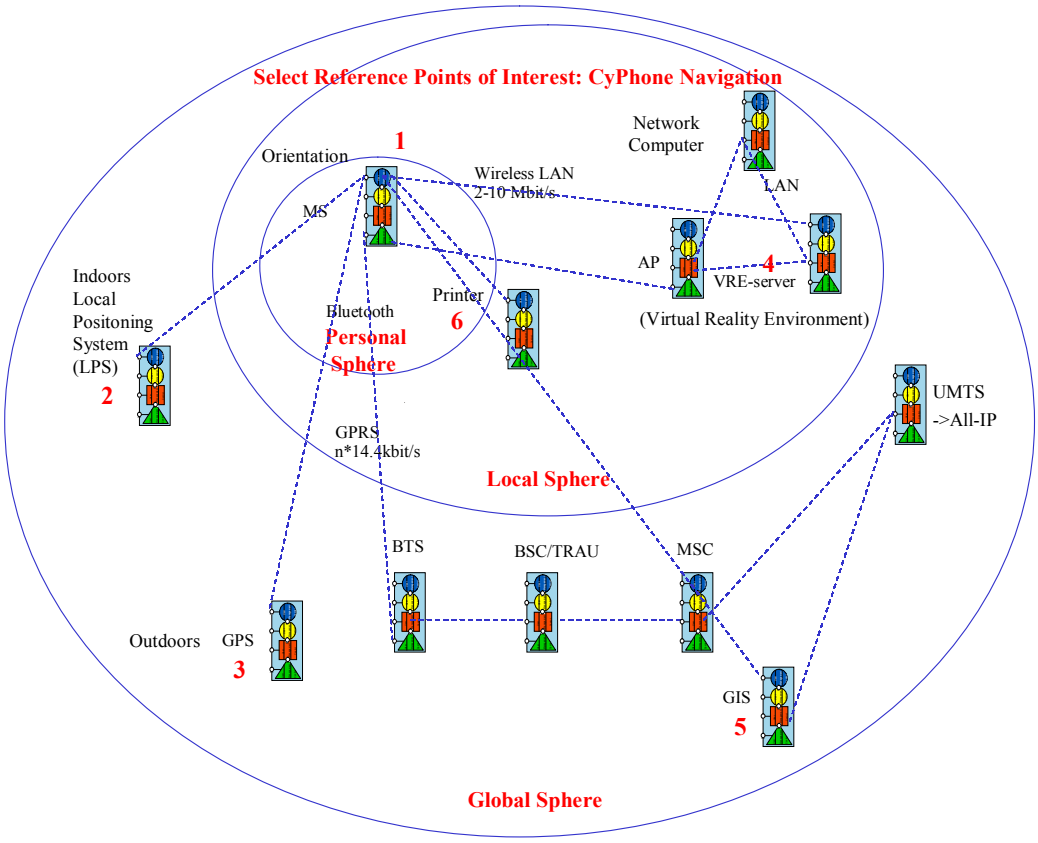
Static Communication Element Description + Reference Point Properties

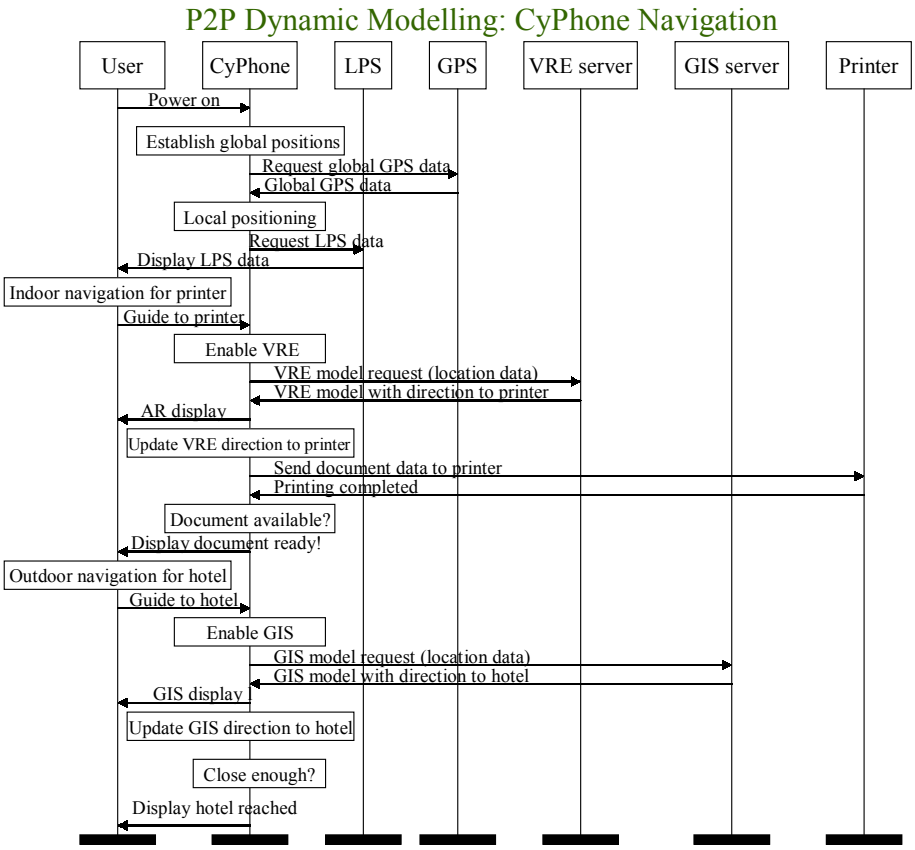


Internal Dynamic Model of Cyberworld & Open Service Platform



- The services join the Lookup server and pass their service objects and additional information on to it.
- The Cyberworld client commits the discovery procedure to find out what kind of services are on offer.
- The Cyberworld client gets the reference to the desired service object.
- The Cyberworld client retrieves the service object and starts using it.




P2P Dynamic Modelling: CyPhone Navigation
User
CyPhone
LPS
GPS
VRE server
GIS server
Printer
Power on
Establish global positions
Request global GPS data
Global GPS data
Local positioning
Request LPS data
Display LPS data
Indoor navigation for printer
Guide to printer
Enable VRE
VRE model request (location data)
VRE model with direction to printer
AR display
Update VRE direction to printer
Send document data to printer
Printing completed
Document available?
Display document ready!
Outdoor navigation for hotel
Guide to hotel
Enable GIS
GIS model request (location data)
GIS model with direction to hotel
GIS display
Update GIS direction to hotel
Close enough?
Display hotel reached

Annex B Acronyms

Acronym	Full Name
CE	**Communication Element**
RP	**Reference Point**
QoS	**Quality of Service**
WSI	**Wireless Strategic Initiative**
WWI	**Wireless World Initiative**
WWRF	**Wireless World Research Forum**
WWRI	**Wireless World Research Initiative**
ASICS	**Application Specific Integrated Circuits**
FEC	**Forward Error Correction**
MIMO	**Multiple Input Multiple Output**
PA	**Power Amplifier**
SIMO	**Single Input Multiple Output**

Annex C References

[1] IST-WSI Project WP2, Deliverable D10: Important technological principles and system options for the elements of the WSI Reference Model, Dec 2002

[2] IST-WSI Project WP2, Deliverable D11: Timeline and Roadmap for the coming of the Wireless World, Dec 2002

[3] National Information Systems Security (INFOSEC) Glossary, NSTISSI No. 4009, January 1999 (Revision 1)

[4] The pre-1999 edition of INFOSEC-99. (See reference for INFOSEC-99 above)

[5] ANS T1.523-2001, Telecom Glossary 2000

[6] WWRF Book of Visions 2001 - http://www.wireless-world-research.org/

[7] Ronald G. Day, Quality Function Deployment: Linking a Company with Its Customers, ASQ Quality Press, Milwaukee, Wisconsin, 1993.

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[9] Parasuraman, A., Zeithaml, V. and Berry, L., A Conceptual Model of Service Quality and its Implications for Future Research, Journal of Marketing, 49, Fall 1985, pp.41-50.